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THE CHALLENGES OF ADAPTING TO CLIMATE CHANGE

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In its Fourth Synthesis Report published in 2007, the Intergovernmental Panel on Climate Change (IPCC) demonstrated that in spite of efforts to reduce greenhouse gas emissions, certain impacts of climate change will be inevitable. Two types of measures are necessary to confront climate change: mitigation measures and adaptation measures. Mitigation measures will make it possible to limit climate change, while the objective of adaptation measures is to reduce the vulnerability of natural and socio-economic systems and thus to react to climate change at least cost.

The adaptation to climate change exhibits certain characteristics that differ significantly from the mitigation of greenhouse gas emissions: (i) the benefits of adaptation policies are of a local nature, while the benefits in the case of the reduction of greenhouse gas emissions are global; (ii) a dual uncertainty concerning the future climate and the impacts of climate change on systems must be taken into consideration in the implementation of adaptation policies; and (iii) continued utilization of frames of reference that may be rendered obsolete in the near future can hinder the development of adaptation measures.

In spite of the complexity of the implementation of adaptation policies, numerous studies such as those by Stern (2006) and Parry et al. (2009) have demonstrated that action must be taken immediately as the costs of the impacts of climate change will be even higher if adaptation measures are not implemented.

In practical terms, the implementation of the adaptation measures must be guided by three criteria. (i) The prioritization of measures: It is essential to establish a proper hierarchy of adaptation measures while promoting the adoption of "no regrets" measures and avoiding the pitfalls of maladaptation, as well as by applying methods such as the minimization of future economic costs or learning from experience. (ii) Governmental intervention: governmental agencies must play a driving role in promoting the implementation of adaptation measures via both the public and private sectors, and specifically by promoting the availability of information and discussion on the subject, as well as by establishing frames of reference consistent with the future climate. (iii) Finally, the adaptation of financing solutions on a case-by-case basis while creating the necessary channels to guarantee that the financing reaches those who need it most.

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INTRODUCTION

In its Fourth Synthesis Report published in 2007, the Intergovernmental Panel on Climate Change (IPCC) showed that in spite of efforts to reduce greenhouse gas emissions, certain impacts of climate change will be inevitable. The response to climate change therefore requires two complementary types of measures: those that are aimed at reducing emissions of greenhouse gases, also called mitigation measures, and those that are aimed at reducing the vulnerability of socio-economic and environmental systems, called adaptation measures.

Mitigation is based on a simple principle. Because the current warming climate results from the accumulation of greenhouse gases in the atmosphere, emissions must be reduced and the storage of greenhouse gases in natural carbon sinks such as forests must be promoted. These measures can be implemented anywhere on the planet. Their impact on the average concentration of greenhouse gases in the atmosphere will be the same.

Adaptation is based on another simple principle. Past emissions of greenhouse gases will have unavoidable future consequences as a result of the long life (several decades or even longer) of greenhouse gases in the atmosphere. Therefore we must immediately take steps to protect ourselves against this future damage, but we must also take advantage of these new climate conditions by adjusting our socio-economic systems. The objective of adaptation policies can also be interpreted as the avoidance or reduction of the potential future costs of climate change.

Although historically mitigation has received the greater part of the attention and effort on the international and local level, mitigation and adaptation policies are two complementary measures. Greenhouse gas emissions reduction efforts are necessary to limit global warming, although they are not by themselves sufficient to eliminate all danger. Adaptation measures, for their part, must make it possible to limit the inevitable consequences of climate change on the most vulnerable populations in particular.

Generally speaking, effective solutions and adaptation measures must be identified starting now. Nevertheless, it is not so easy to decide when and how they should be implemented at the local level. This report attempts in particular to present guidelines for a discussion on the subject of adaptation. The first section relates to the definition and interconnection of the two pillars of the struggle against climate change, i.e. mitigation and adaptation. We then explain the context in which adaptation measures to climate change are implemented, such as the local aspect of the adaptation, the uncertainties relating to both the future climate and the impacts on our societies as well as the role of frames of reference in adaptation. The third section focuses on a demonstration of the urgency of implementing adaptation measures, starting immediately. The final section analyzes the selection and implementation of adaptation measures.

I. TWO APPROACHES IN THE STRUGGLE AGAINST CLIMATE CHANGE: MITIGATION AND ADAPTATION

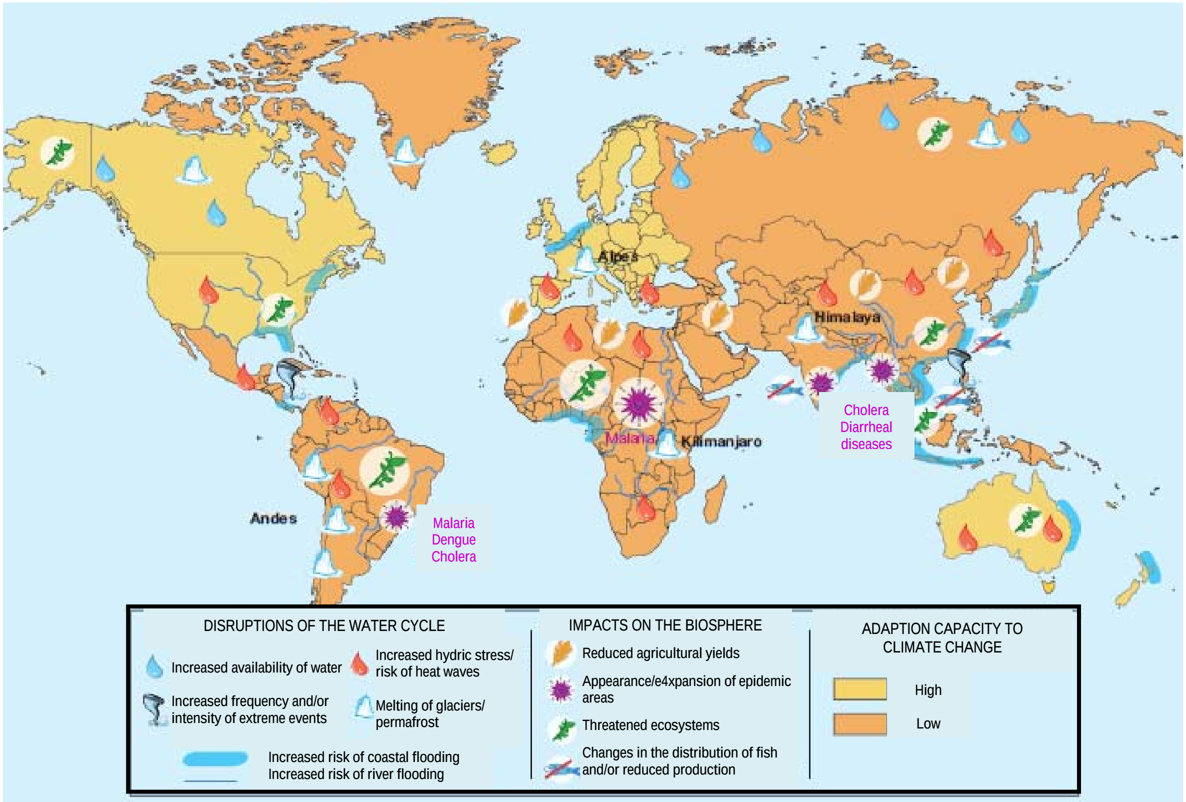
A. The future climate will be different from today's climate

In its most recent assessment report published in 2007, "Climate Change 2007: Assessment Report", the Intergovernmental Panel on Climate Change (IPCC) warns that even if we are able to limit our emissions of greenhouse gases, the average worldwide surface temperature will rise by several degrees. The report also indicates that if we are to have any prospect of limiting this increase to + 2°C compared to the pre-industrial era, the concentration of greenhouse gases in the atmosphere should not exceed 450 parts per million (ppm). Further, the more global warming is limited, the lower the costs of responding to its impacts are limited.

These impacts of climate change will result primarily from the increase in temperature and changes in precipitation patterns. They will impact both average climate conditions as well as their extremes, with significant repercussions on health, the economy and natural systems.

The effects of climate change will be felt everywhere, although very differently in the diverse regions of the world. For example, the continents will heat up more rapidly than the oceans, as will regions in the high latitudes. In addition, one major impact of the increase in temperature, the rise in sea level, will threaten populations living on small islands or in low-lying coastal areas as well as the river deltas of South and East Asia. According to the IPCC, the average sea level has risen by 1.8 mm/year since 1961 and by 3.1 mm/year since 1993. The United Kingdom’s national weather service, Met Office, predicts that in 2075 exceptional rises in sea level combined with an average rise of 53 cm would cause floods each year that could affect up to an additional 150 million people in three-quarters of Asia. Africa, the Caribbean islands, the Indian Ocean and the Pacific would also be included among the affected regions.

Figure 1 – Projected principal impacts of climate change



Source: CDC Climat Research based on data from the IPCC (2007).

This inequality of the distribution of the impacts of climate change will also affect precipitation patterns. Certain regions such as the Mediterranean Basin, South Africa and South America will experience increasing periods of drought as well as a reduced availability of water as a result of changes in the flow of rivers and the melting of glaciers. Extreme phenomena such as hurricanes or very violent thunderstorms will be more frequent and more intense, causing urban flooding and landslides in areas that are already subject to these events, such as the Montpellier region in France.

B. Clarification of the concept of adaptation

The definition of the mitigation of greenhouse gas emissions is clear and unambiguous. Mitigation means reducing emissions or increasing the storage of emissions in non-atmospheric sinks. On the other hand, adaptation measures can be defined in a number of different ways.

Adaptation to impacts

According to the IPCC (2001), adaptation is the adjustment of natural or human systems in response to current or expected climate change (or to its effects), to moderate negative consequences and take advantage of any opportunities. Adaptation strategies can also be defined along the lines of Mendelsohn (2006) as the changes that people, companies or governments make to reduce the damage (or increase the benefit) of climate change. More recently, the Copenhagen Agreement (2009) has expanded the concept of adaptation by adding a new point to the current generally accepted definition of the concept of adaptation to the negative effects of climate change, i.e. adaptation to the impacts of mitigation measures.

Nevertheless, the point that all these definitions have in common is that the anticipation of a future climate that is different from the current must lead to changes in the current behaviors of individuals and systems on the basis of predictions about the future climate. Adapting therefore does not consist solely of analyzing the vulnerability of territories[2] or actors to expected climatic evolutions, but also of implementing suitable measures. That is why the analysis *of the impacts* of climate change differs significantly from the analysis of the *adaptation* to these impacts, which is the subject of this study.

Some adaptation measures will be implemented independently. Individuals and societies will change the technologies they use and will incorporate new practices, but it will also be necessary to plan certain changes, and this responsibility is ultimately in the hands of the government.

Reactive adaptation versus anticipatory adaptation

An adaptation measure is called "reactive" when it is taken in direct response to a major climatic event. One very good example of a reactive adaptation measure is the case of the city of New Orleans and its vulnerability to hurricanes higher than Category 3. Although this vulnerability was well known to engineers and politicians, no adaptation measures were taken before Hurricane Katrina.

Figure 2 illustrates this type of response to climate risks.

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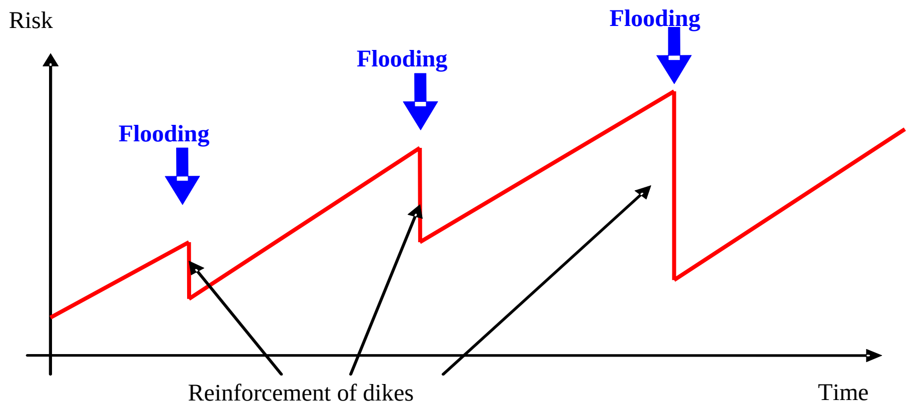
[2] The *vulnerability* of a territory or business to the physical impacts of climate change can be defined according to the IPCC as the ability of a system to react to the prejudicial effects of climate change, including the effects of climate variations and climatic extremes.

The word *territory* is used here to designate a geographic perimeter administered by a political structure (city, community, region, Nation State etc.) in which specific policies can be adopted, for example in the context of the fight against climate change.

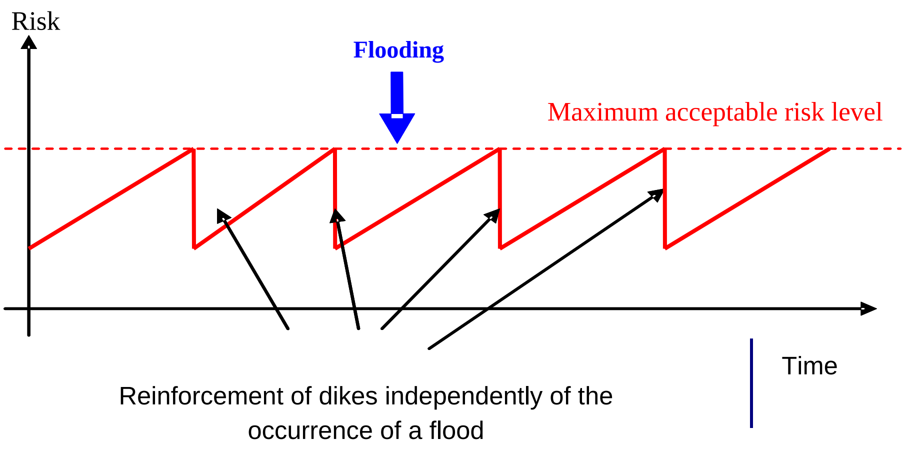
Figure 2 – Timing of reactive adaptation measures (in this case the reinforcement of dikes) in the face of the risk of a major climatic event (in this case flooding)



Source: Hallegatte (2010).

In contrast to the previous example, adaptation measures can be taken before the occurrence of the extreme phenomenon (in this case a flood). For example, a Dutch law defines a maximum acceptable risk of flooding. Adaptation measures are taken when the maximum acceptable risk is reached. This type of adaptation measure is called anticipatory (or proactive) when it is taken before the climatic risks actually occur.

Figure 3 – Timing of anticipatory adaptation measures (in this case the reinforcement of dikes) in the face of the risk of a major climatic event (in this case flooding)



Source: CDC Climat Research based on data from Hallegatte (2010).

Reactive adaptation measures do not include a continuous management of the climatic risk. Anticipatory adaptation policies manage this risk over the long term by keeping the level of the risk within an interval defined by political and social consensus.

It should be noted in this context that regardless of the type of adaptation measures, it is not possible to completely eliminate the climatic risk, partly on account of the magnitude of the costs associated with eliminating the risk altogether, but above all because even without any change in climate, absolute protection from risk is impossible.

Spontaneous adaptation versus planned adaptation

Spontaneous adaptation includes the adaptation measures that are taken naturally without any specific coordination. Since the beginning of history, human societies have adapted to changes in their climate, for example by changing the crops they raise or modifying their building methods. Nevertheless, this spontaneous adaptation by itself will not necessarily be sufficient, given the scope and rapidity of the climate change expected by the IPCC. Moreover, it should be emphasized that the actions taken by certain parties to protect themselves against climate risks can simply result in shifting the risk to other geographical areas or populations or can trigger other impacts. The overall effect of several spontaneous adaptations can be the opposite of what was intended, which is one reason for the importance of implementing planned adaptation measures.

We must not forget that spontaneous and planned adaptations are also intimately linked, as spontaneous adaptation actions can frequently be carried out thanks to the existence of a pre-existing environment which was the result of prior planning. For example, the irrigation of fields during a drought is a spontaneous adaptation measure only if the infrastructure that makes irrigation possible is already in place.

To promote the planning of adaptation measures, the Department of Energy and Climate of the French Ministry of the Ecology, Energy, Sustainable Development and the Oceans (MEEDDM) recently published a report evaluating the cost of the impact of climate change and adaptation in France. Following the publication of this report, the French State plans to prepare a National Plan for Adaptation to climate change by 2011. Other countries such as Spain and Germany have already drafted their own national adaptation plans.

C. The unique features of adaptation measures compared to mitigation policies

Mitigation measures are perceived as a means to combat climate change and adaptation measures as a means to react to them. It is therefore important to emphasize that these two strategies are intimately linked by two elements.

First, adaptation measures require the adoption of mitigation measures to avoid situations in which adaptation is no longer possible. Without emissions reduction measures, adaptation will in fact be impossible for some systems or agents. For example, if global emissions are not limited in time, certain small island countries such as Tuvalu could disappear as a result of a increase in sea level. Therefore, with an eye toward limiting the costs linked to climate change, it is preferable to attack the problem at the source (and therefore to reduce greenhouse gas emissions) rather than try in vain to adapt to every change in climate.

In addition, certain adaptation strategies also make it possible to reduce greenhouse gas emissions. For example, promoting afforestation to preserve soils, as in the Landes (South-Western France), is an adaptation strategy which simultaneously makes it possible to store CO_2. On the other hand, other adaptation strategies such as those that require the use of techniques or materials that emit greenhouse gases (e.g. the use of individual air conditioning or recourse to artificial snowmaking techniques in ski areas) can run counter to the objective of reducing emissions.

Nevertheless, the adaptation to climate change has two unique features in comparison to mitigation which means that the two categories of measures cannot be considered identical.

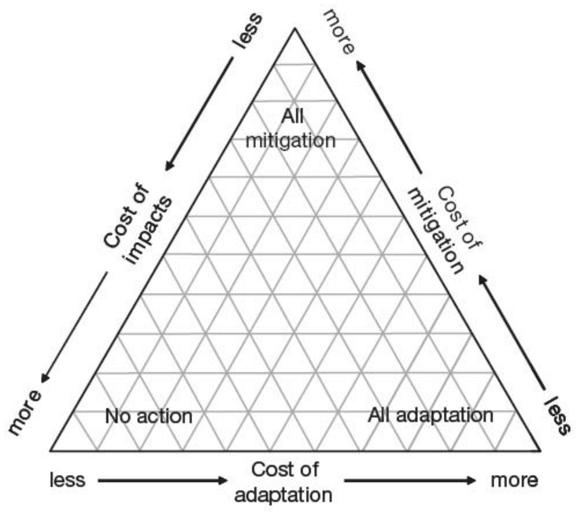
While emissions reductions are always quantified using the same unit regardless of the action taken (one metric ton of CO_2 equivalent), it is much more difficult to measure, much less quantify, the benefits of adaptation with a single unit. It is therefore difficult to assess the potential economic value of the preservation of an area at risk of flooding. This seriously complicates the comparison of the adaptation measures and their prioritization.

Finally, the time horizons of the benefits of the adaptation and mitigation measures may be different. The benefits of adaptation measures in terms of a reduction of current vulnerability are immediate. For example, the preparation of an evacuation plan for a flood zone or a plan to reduce the impacts of dry periods reduces the vulnerability of a territory as soon as the measures are adopted, regardless of the occurrence or non-occurrence of the extreme climatic phenomenon in question. On the other hand, because greenhouse gases remain in the atmosphere for a long time, the implementation of emissions reductions measures does not reduce vulnerability to climate change instantaneously, although it does reduce vulnerability over the long-term. In the long run, therefore, both types of measures to combat climate change contribute to a reduction in vulnerability.

The consequences of adaptation and mitigation measures on the costs of climate change

As illustrated in Figure 4, the adoption of measures to confront climate change, both in terms of adaptation and mitigation, has a direct cost. These measures also create benefits by making it possible to reduce the economic, environmental and social costs linked to the impacts of climate change.

Figure 4 – The role of adaptation and mitigation measures in the reduction of costs linked to the impacts of climate change



Source: Parry (2002).

Although a cost-benefit analysis of emissions reduction and adaptation measures is difficult on account of uncertainties that prevail with regard to climate change, one thing is certain: a reduction of greenhouse gas emissions today, although it will not eliminate all risk of climate change, will make it possible to reduce the scope of future climate changes. Therefore, by accepting an increase in the costs of mitigation (and therefore a major effort to reduce emissions), the costs of the impact of climate change will be lower (top point in Figure 4).

Moreover, without the implementation of adaptation measures, the costs of the impacts of climate change will be higher (lower left point of Figure 4). In that case, the negative effects of the climate change will be greater and the socio-economic systems less well prepared to benefit from potential advantages.

Therefore, the more we are able to reduce emissions (and thus the impact of climate change), the less we will need to adapt to the consequences of climate change. In other words, mitigation and adaptation to climate change are two issues that are intrinsically linked. If few mitigation measures are put in place, it will take much more in the way of adaptation measures to respond to the greater climate change (lower right point of Figure 4).

Finally, we must not forget that there are measures such as thermal insulation in buildings that make it possible to simultaneously reduce greenhouse gas emissions and to adapt to climatic impacts. These types of measure makes it possible to achieve both emissions reduction and adaptation objectives.

II. THE COMPLEXITY OF ADAPTATION POLICIES

In spite of the urgency of implementing adaptation measures, the planning and large-scale implementation of adaptation measures to climate change are still in an embryonic phase. There are significant limits to their development, such as the local character of the adaptation, which makes the coordination of policies more difficult; the uncertainties linked to both the impacts of climate change and the vulnerability of natural and economic systems; as well as the outdated nature of certain laws, regulations and standards.

A. The local character of the benefits of adaptation policies

In spite of the need to implement climate policy on the national level, adaptation and mitigation measures are still realized at a very local level. That is the case, for example, of the construction of a dike in a specific location to protect a coastal city from a rise in sea level, or emissions reductions in a thermal power plant.

Nevertheless, the benefits of these two types of actions must be considered on two very different scales. The emissions reduction achieved by a thermal power plant, for example, benefits everyone on the planet by limiting the concentration of atmospheric greenhouse gases. On the other hand, adaptation measures such as the construction of a dike primarily benefit the system that is exposed to the impact, in this case the coastal city or the populations with the greatest exposure and to protect which a measure has been implemented[3]. That means (i) that to achieve an effective and equitable reduction of greenhouse gas emissions, the principal emitters on the world level must be involved, (ii) that it is possible to modify the location of the emissions reductions, unlike adaptation measures, and (iii) that the willingness at the local level to pay for these two types of actions is very different and will have implications on the economic incentives required to achieve emissions reductions and adaptation measures.

The question of the location of climate policies is an important point. The impact of an emissions reduction on climate change is the same regardless of the location of the emissions reduction. That means that the emissions reduction can be decentralized and therefore implemented where it is the least expensive.[4] That is not the case with adaptation. In fact, adaptation relates to a particular territory (a city, a coast, an infrastructure network etc.) and climatic impacts on this territory (an increase in the average temperature, a reduction in precipitation etc.). That explains two characteristic traits of the implementation of adaptation measures: (i) they must be carried out on the territory to be affected, even if the same measure would be less expensive if implemented elsewhere, and (ii) they must be defined as a function of the territory and the its anticipated future climate.

The implications of these two characteristics are extremely important. First, adaptation strategies must be adjusted to suit each problem encountered. Adaptation strategies are therefore difficult to generalize and export, and most of the time they cannot achieve their objectives if they are applied in another territory. Incentives for the development of adequate adaptation policies must take this local aspect of adaptation into consideration as well as the benefits of the adaptation for all the parties involved.

[3] For example, in reaction to a decrease in snowfall in the Alps, the operators of ski resorts are using man-made snow, which has an adverse effect on other parties via the increase in greenhouse gas emissions.

[4] The flexibility mechanisms of the Kyoto Protocol are based on this principle and make it possible, for example, to implement greenhouse gas emissions reductions projects in countries that have not made any emissions reduction commitment, as well as the trading of emissions permits among countries that are bound by emissions commitments.

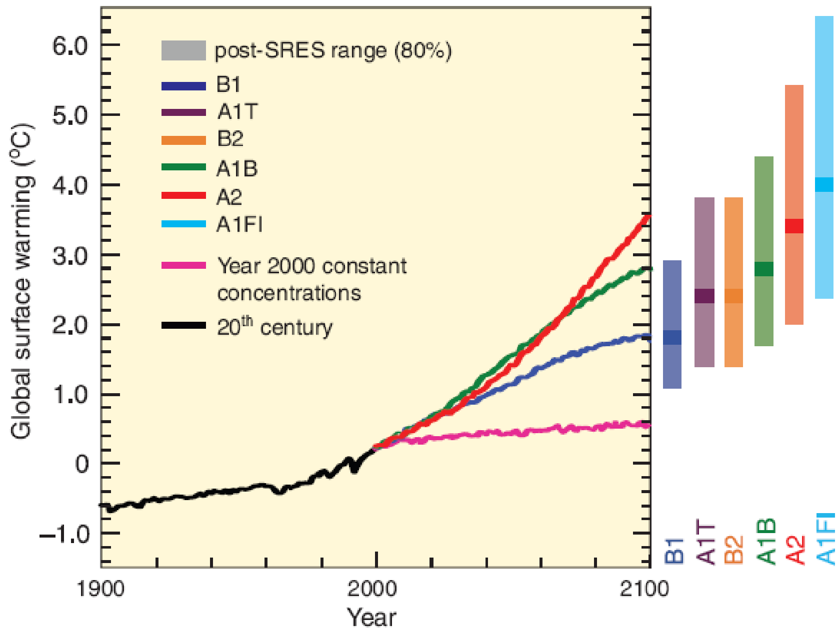
B. The dual uncertainty concerning the future climate and vulnerability

Climate policies must take two uncertainties into account: (i) uncertainty about the future climate and (ii) uncertainty about the impacts of climate change on natural and socio-economic systems as a result of our incomplete knowledge of the vulnerability of territories and feedback mechanisms.

Uncertainty about climate change

In its fourth report published in 2007, the IPCC describes different projected trends of average worldwide temperature between now and 2100 on the basis of several scenarios. These scenarios are based on hypotheses concerning economic growth, greenhouse gas emissions and population growth, among other factors, to model the future climate. As illustrated in Figure 5, the results of these projections can differ significantly depending on the hypotheses adopted. Although all the scenarios lead to an increase in the average temperature of the planet between now and the end of the 21st Century, not all of them project increases of the same scope. Therefore it must be concluded that the adaptation actions cannot be identical, but rather depend on whether we consider the increase of the average temperature between 1.1 and 2.9°C predicted by Scenario B1 – which is a rather optimistic scenario in terms of emissions – or the increase between 2 and 5.4°C predicted by Scenario A2 – which is among the most pessimistic scenarios proposed by the IPCC.

Figure 5 – Models of surface temperature between 2000 and 2100 for different scenarios



Source: IPCC, Report No. 4, 2007a.

These scientific projects which confirm the likelihood of future climate change cannot, however, give estimated ranges of the expected increase in temperatures which are sufficiently precise that they would enable us to predict the scope of the impact with a low margin of error. This uncertainty, which results from the complexity of the physical mechanisms that contribute to the climate, adds to that already surrounding the scope of the emissions reductions campaigns to be undertaken, actual economic growth, world population increase etc. This broad array of potential climate risks makes it difficult to implement adaptation measures. For example, the situation is completely different from the point of view of the measures to be taken, the incentives created and the costs incurred in adaptations depending on whether we expect a rise in sea level by 50 cm or by 1.5 m.

Box 1 – The differences between climate projections and climate predictions.

Climate projections are estimates obtained using different computer models simulating "artificial planets", on the basis of the laws of physics (conservation of mass, energy, fluid dynamics etc.). These models are validated by their ability to reproduce the observed climate and its characteristics. These models do not attempt to "predict" the weather that will be experienced on a given day in the future (e.g. January 1, 2050), but to calculate statistical averages (e.g. the average temperature of the month of January between 2050 and 2080). These models simulate the signs of climate change, to which we must add natural variability, i.e. climate fluctuations of natural origin. This natural variability is currently largely unforeseeable. Over the next 20 years, the effects of climate change will remain low compared to the natural variability, which means that it is currently impossible to clearly demonstrate the impacts climate change for the period up to 2030. Beyond that, the effect of climate change becomes must greater than that of natural variability and can thus be estimated with less uncertainty. Inversely, the objective of predictions is to obtain, for a given variable, the value closest to its real value in the future. It is currently possible to make very accurate predictions over the very short term (1 to 9 days), up to a time horizon of one year. Research is currently being conducted to obtain predictions over a period longer than 10 years by including, among other things, the impact of ocean cycles.

The local aspect of adaptation also makes it necessary to have climate projections on the scale of territories, whether at the level of a region or a city. Currently, this “regionalization” of global climate models[5] remains complex and is not very well developed on a precision scale for which the number of hypotheses that must be taken into consideration increases the level of uncertainty. With the development of simulations that utilize small-scale geographic models, it will be possible to reduce these uncertainties and to use them as a tool in making decisions in the context of local adaptation policies.

Shorter-term predictions of the future climate on the local scale will also be very useful in making decisions in the framework of local adaptation policies.

Uncertainty linked to the vulnerability of natural and socio-economic systems

The same physical impact of climate change will have different consequences depending on where it takes place. For example, a rise in sea level by 50 cm over a steeply sloped and relatively unpopulated coast will not have the same implications as the same rise in sea level in a heavily populated delta where the average height above sea level does not exceed 2 meters. The potential consequences of climate impacts must therefore be studied case by case to develop appropriate adaptation measures.

Numerous scientific reports evaluate the impacts of climate change on ecosystems. Boe (2007), for example, analyzes the impact of changes in precipitation patterns on the flow of rivers in France. Lebourgeois (2001) studies the impacts of past climate variations on forest ecosystems.

Other projects such as the Stern Report (2006), Agrawala and Fankhauser (2008) and Parry et al. (2009) evaluate the impacts of climate change in terms of economic costs (see Section III for a detailed analysis of these cost estimates). All the results of these studies are based on future climate hypotheses which could turn out to be inaccurate as they are overestimated or underestimated by the models in question.

Nevertheless, the uncertainty concerning the scope of the impacts of climate change on natural and socio-economic systems should not delay the implementation of appropriate adaptation measures. The existence of these uncertainties must not result in the adoption of an adaptation solution which is best suited to only *one* of the scenarios (e.g. the most pessimistic), rather the solution that is best suited to the greatest number of possible scenarios. If the territory is located 40 cm above sea level, regardless of whether the long-term rise in sea level will be 50 cm or 150 cm, the most important thing in terms of

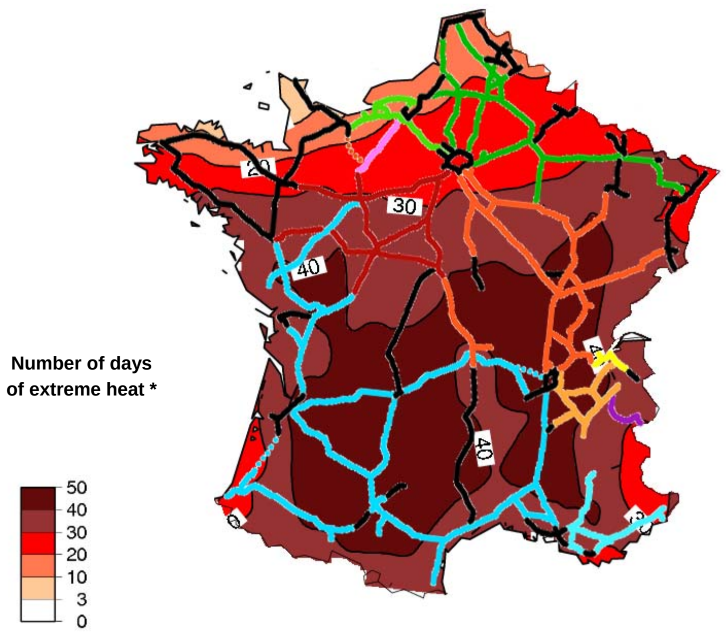
[5] A climate model is a mathematical model of the climate in a given geographic area.

making a decision today in a risk situation is the knowledge that there will be a rise in sea level. It is crucial not to delay the implementation of solutions, or at least to initiate discussions regarding the appropriateness of actions. The decision to act now or later will depend, as we shall see in Sections III and IV, on the costs of the planned adaptation measures as well as the availability of financing, two elements in the prioritization of the adaptation measures.

C. The need to revise our frame of reference based on historical climate data

The existing standards and regulations, which have been prepared on the basis of past climate data, may be obsolete in the near future as a result of climate change. That is particularly true for the standards and regulations relative to structures and infrastructure, the useful life of which is on the order of several decades and will therefore be impacted by changes in the climate. Technical standards must therefore be revised to respond to the projected climate stresses. For example, the base layer of French roads is currently designed according to uniform criteria regardless of the location of the road, and therefore without regard to climate conditions. As shown in Figure 6, however, the different regions of France will experience significant impacts which will differ depending on their geographic location. Because the temperature has a major effect on the stability of a roadway, it would be appropriate to reassess the existing frames of reference.

Figure 6 – Principal French highways and estimates of the number of days of extreme heat expected in 2100 compared to the 1960-1989 average, according to Scenario A2



* Number of days for which, in an interval of at least six consecutive days, the temperature in 2100 is projected to exceed by more than 5 °C the 1960-1989 average temperature of five days around the same calendar date.

Source: Cochran (2009).

Adapting standards to climate change is particularly important for the construction of new infrastructure. Guérard and Ray (2006) present a highly enlightening example of what happens when climate changes are not taken into consideration in the reconstruction of an infrastructure destroyed by an extreme event. In their case study, several bridges in Peru that were destroyed in 1983 by an El Niño episode (the return period of which was then estimated at 50 years) were rebuilt on the basis of the old standards. 15 years later, i.e. much sooner than expected on the basis of the average return period, another El Niño episode occurred with the same destructive effects for the infrastructure. This time, an alternative solution including the construction of submersible fords and "fusible" bridges, for use in case of a violent climatic event, were installed in critical locations, while still allowing the infrastructure to be used under normal conditions.

This example illustrates two key concepts:

- The solutions to be implemented are not only technical (modify infrastructure to more effectively meet requirements) but also organizational (crisis management, risk management and management of return to normal).
- Even in the infrastructure sector it is possible to find gradual adaptation solutions that require management actions and changes in habits, such as decisions not to use the bridge during the crisis period, rather than a more severe adaptation in the form of direct investments in more expensive infrastructure such as bridges that can withstand the El Niño event.

If we consider that the current extreme events may become regular events in the future, it will be necessary to adapt the old standards to these new conditions of use and to analyze the adequacy of current crisis management measures. That's not an easy process, although feedback from crisis management is already available to help define alternative solutions, such as the case study presented here concerning the management of the El Niño phenomenon in Peru.

Nevertheless, adapting means more than simply anticipating an increase in the frequency of extreme events today, because the future climate is not a simple extrapolation from the past. It remains essential to conduct research to define new indicators and tools to make possible the development of methodologies that are or can be adapted to each individual case. The utilization of climate scenarios that are based on different models can be an initial source of information. Longer-term climate forecasts (which are being developed) may also turn out to be very useful to help in making decisions in relation to both the adaptation of the different standards and choices of locations for the new infrastructure.

Although a transition from old standards to new ones is necessary to make it possible to take climate change into consideration at a reduced cost in the development of new projects, we must not forget that climate change will also have a very significant impact on the existing infrastructure which has been built according to the standards that were defined on the basis of past climatic conditions. In this case, specific adaptation measures have already been implemented and must continue to be implemented.

III. THE URGENCY OF TAKING IMMEDIATE ACTION

A. The costs linked to the impact of climate change will be higher without adaptation and mitigation measures

Investing in mitigation and adaptation actions today makes it possible (i) to reduce the overall cost of damage due to the impact of future climate change and (ii) to reduce future investments as the need for adaptation measures will be reduced.

These costs are difficult to estimate because of several factors. First, the uncertainty linked to climate projections makes it difficult to calculate the scope of the physical impacts. On top of this uncertainty is the additional that of the local applicability of the climate models. It is also very difficult to calculate the costs of the physical impacts of climate change when they relate to non-commercial goods and services which do not have clearly identified prices. Finally, we must add the temporal dimension of the cost estimates. The rate of inflation used to compare potential financial damage and benefits on different dates can have a significant impact on the result of the calculation.

In spite of these difficulties, in 2006 the Stern Report estimated that the costs of the impact caused by climate change would be 5 to 20 times higher than the costs that would be incurred today to effectively combat the greenhouse effect.

Other, more recent works such as those by Parry et al. (2009) conclude that the financing necessary for the transition to a low-GHG emission economy adapted to the future climate is on the order of several trillion dollars a year. In this study, the authors compare the estimate of the costs of the impacts of climate change under two scenarios: the IPCC Scenario A2 which does not include emissions reduction measures and the 450 ppm scenario of the International Energy Agency, which does include mitigation measures.

Beyond their inclusion or exclusion of mitigation and adaptation policies, these scenarios differ in some of the hypotheses they adopt. For example, the A2 Scenario does not take into consideration any reduction of greenhouse gas emissions and is characterized by slow economic growth and technological progress, average and continuous population growth, little world trading in allowances, self-sufficiency of regions and the preservation of local socio-economic characteristics. On the other hand, the IEA's 450 ppm scenario, in spite of a rise in the demand for primary energy by 20% between 2007 and 2030, foresees the accelerated implementation of low-emission technologies: nuclear energy, renewable energy sources, the capture and storage of CO_2, zero-emissions vehicles etc.[6]

Table 1 presents the results of these studies which show that the adjusted cumulative average cost of the impacts of climate change could decrease in terms of cumulative value from USD 1,240,000 billion, an estimate based on Scenario A2 with no adaptation, to USD 275,000 billion, an estimate made on the basis of the IEA's 450 ppm scenario with adaptation. This reduction of the cumulative average cost of the impact by USD 965,000 billion dollars is possible thanks to:

- The implementation of mitigation measures. In this case, the reduction of the cumulative average cost of the impact is USD 830,000 billion, corresponding to the transition from Scenario A2 (at a cost of USD 1,240,000 billion) to theIEA's 450 ppm scenario (at a cost of USD 410,000 billion), which includes mitigation policies (but no adaptation).
- The implementation of adaptation measures. The cumulative average cost saving of the impact is illustrated by the transition from the IEA's 450 ppm scenario, which does not include adaptation measures, to the IEA's 450 ppm scenario with adaptation. The reduction of the cumulative average cost of the impact is USD 135,000 billion (410,000 - 275,000).
- The simultaneous implementation of both types of measures (adaptation and mitigation). For example, implementing an adaptation policy without mitigation measures (Scenario A2 with adaptation) results in a cumulative average cost of the impact which is higher (USD 890,000 billion) than that incurred after the combined implementation of mitigation and adaptation policies (IEA's 450 ppm scenario with adaptation, the cost of which is USD 275,000 billion).

In conclusion, we note that in comparison to these reductions of the cumulative average cost, the cost of the implementation of climate policies is very low: on the order of USD 110,000 billion for the mitigation measures and USD 6,000 billion for adaptation policies, they represent respectively 13% and 5% of the reduction achieved in the cumulative average cost of the impacts.

[6] The average increase in temperature in Scenario A2 would be 3.4°C (with a range between 2°C and 5.4°C), while the average increase in the IEA's 450 ppm scenario would be in a range between 1.5°C and 3.9 °C.

Table 1 – Estimated costs of climate policies to be implemented under different scenarios

Scenario		Adjusted cumulative average cost (2000) (billions of dollars)	Annual cost in 2060 (billions of dollars)
Scenario A2 (without mitigation)	Cost of impact of climate change (without adaptation)	1,240,000	2,400
	Cost of impact of climate change (with adaptation)	890,000	1,500
	Costs of implementation of adaptation measures	**6,000**	na
450 ppm scenario (with mitigation)	Cost of impact of climate change (without adaptation)	410,000	1,900
	Cost of impact of climate change (with adaptation)	275,000	1,200
	Costs of implementation of adaptation measures	**6,000**	na
	Costs of implementation of mitigation measures	**110,000**	na

Note: Three types of impacts are noted here: (i) economic impacts, which are impacts on production and income (GDP) (ii) non-economic impacts - social and environmental (health, biodiversity, etc.) and (iii) discontinuity impacts linked to the increased risk of natural disasters and other extreme climate events.

"na" indicates no data available.

Source: CDC Climat Research based on Parry et al. (2009).

Finally, Bruin et al. (2009) demonstrate using the two integrated assessment models that investment in a good adaptation policy is all the more necessary when the mitigation strategies are insufficient. Further, the inverse is also true that the investment in the reduction of greenhouse gas emissions is all the more necessary when the optimal levels of adaptation are impossible to achieve.

B. Costs linked to adaptation to climate change

Table 2 presents the results of the principal reports relating to the costs and benefits of adaptation measures.

Table 2 – Evaluation of investments required for adaptation in billions of dollars annually

	Territory covered	Annual costs
World Bank (2006)	Adaptation investments in developing countries	9-41
Stern Report (2006)	Adaptation investments in the OECD countries	15-150 0.05-0,5 % of GDP
UNFCCC (2007)	Additional adaptation investments necessary in the world in 2030	49-171

Agrawala and Fankhauser (2008) find that these cost analyses have been conducted using different approaches: by a sectoral approach (sectors such as agriculture, energy or infrastructure are studied separately), by a multi-sector estimate at the national level (in particular in the case of the less advanced countries) or by a worldwide multi-sector approach.

The three principal conclusions of their study are that:

- The risks envisaged by the studies are limited and relate primarily to average trends, ignoring extremes. Numerous phenomena are therefore overlooked by these methods of evaluating costs.
- The adaptation costs depend on the adaptation measures adopted.
- It is difficult to precisely determine the extra costs generated by a variable climate in the economic calculation that is supposed to guide decision-making, primarily on account of the existence of a multitude of additional factors (economic growth, demographic changes, aging and maintenance

procedures for infrastructure etc.) This would require more in-depth research to better define the limits of climate change.

Elsewhere, Drouet (2009) analyzes the limits of the cost calculation methodologies used in these studies and shows that they relate both to the scope of the physical impact of climate change and to the economic valuation of these changes. Nevertheless, these figures indicate an order of magnitude and confirm that cost will increase over time (as the longer we wait, the more it will cost) and are very useful for initiating discussion and starting the implementation of adaptation measures.

A new study conducted in 2010 by the group Economics of Adaptation to Climate Change (EACC) analyzes sector by sector the costs linked to adaptation by distinguishing between two extreme scenarios, one "wet" and the other "dry"[7], and by comparing them to the scenarios adopted by the UNFCCC and Parry et al. (2009). The resulting cost estimates are higher than the high range of the 2007 UNFCCC study, as shown in Table 3. The results indicate that coastal areas and infrastructure are the sectors that are most vulnerable to the impact of climate change in economic terms because they reach represent more than 30% of the estimated total costs of adaptation.

Table 3 – Comparison of the estimated adaptation costs for each sector according to several studies (in billions of dollars)

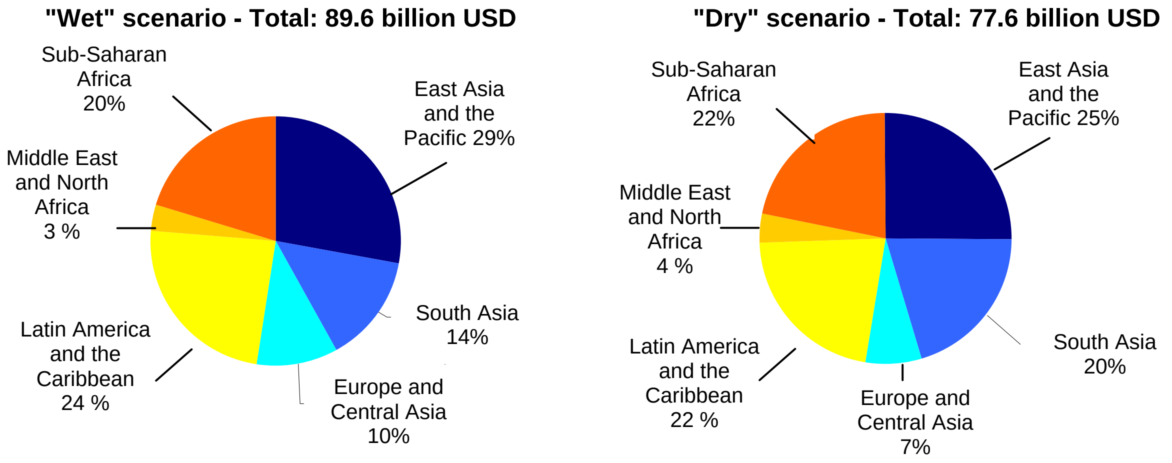
			EACC Study	
Sector	**UNFCCC (2007)**	**Parry et al. (2009)**	**“Wet” scenario**	**“Dry” scenario**
Infrastructure	2-41	18-104	29.5	13.5
Coastal areas	5	15	30.1	29.6
Water supply and protection against flooding	9	> 9	13.7	19.2
Agriculture, forestry and fishing	7	> 7	7.6	7.3
Health care	5	> 5	2	1.6
Extreme climate events	-	-	6.7	6.5
Total	28-67	-	89.6	77.7

Source: Economics of Adaptation to Climate Change study team (2010)

In addition to these estimates, the authors of the EACC study also estimate the total costs of adaptation by region (see Figure 7). Of the USD 89.6 billion in costs estimated with the "wet" scenario, more than 27% relate to East Asia and the Pacific, and more than 23% to Latin America and the Caribbean. If we consider the "dry" scenario, these percentages remain similar. According to these studies, Europe and Central Asia as well as the Middle East and North Africa are the regions where the costs will be lowest.

[7] In fact, the different projections based on IPCC Scenario A2 assume similar temperature increases. However, they differ in their projected levels of precipitation. In this report, the authors have used two extreme models: the Commonwealth Scientific and Industrial Research Organization model (CSIRO, Australia), for the "dry" scenario and that of the National Center for Atmospheric Research (NCAR, USA) for the "wet" scenario.

Figure 7 – Total costs of adaptation by region for the period 2010-2050 (in billions of dollars)



Source: Economics of Adaptation to Climate Change study team (2010).

The separate estimation of the costs of mitigation and adaptation probably introduces a bias linked to the failure to take into consideration potential interactions between these two aspects of climate policy. Nevertheless, these estimates are necessary to start discussion and support the argument about the need to implement adaptation measures.

IV. Selection and implementation of adaptation measures

Up to now we have discussed the issues surrounding the definition of adaptation measures, the specific factors that must be taken into consideration in their implementation and the costs they entail. We have also explained the need to implement adaptation actions stating now. In this final section of our report, we will look at the selection and implementation of the adaptation measures and the problems that must be taken into consideration.

A. *Prioritizing adaptation measures*

Because the resources available to finance adaptation measures are limited, it is essential to prioritize their implementation. To do so, we must be aware of the adaptation priorities and must be able to gauge the success of different measures. However, we do not yet have sufficient indicators of the appropriateness of adaptation measures, as it is difficult to assess the vulnerability of the territories and to measure the success of the adaptation measures undertaken. That makes prioritizing adaptation measures particularly difficult for the parties involved. More research in this field is urgently needed.

Promoting "no regrets" measures

The lack of indicators capable of assessing adaptation policies, combined with the specific characteristics of resulting measures and the uncertainty linked to climate change and its impacts (See Section II), supports giving priority to measures which have been dubbed "no regrets" measures.

According to Hallegatte (2008), an adaptation measures is considered a "no regrets" measure if there is no reason to regret the decision even if the risk it was designed to counter fails to materialize. That means that there are reasons to carry out the measure besides simply adaptation. For example, the reduction of greenhouse gas emissions to lessen the impact of climate change is a "no regrets" measure because this reduction has other positive effects such as the concomitant improvement of air quality which has a direct impact on health. Employing the same logic, the upgrading of rainwater runoff systems is also a "no regrets" measure.

Avoiding the pitfalls of *maladaptation*

Maladaptation is the implementation of adaptation measures that turn out to be ineffective once the impacts of climate change materialize (OECD, 2009). These measures are generally very expensive in relation to any benefits they produce and are often found in the framework of an inflexible adaptation policy, i.e. one that involves the construction of infrastructure.

The Maginot Line, which was built in Eastern France between the two World Wars to counter the risk of a repeated German invasion, is an enlightening example of a maladapted strategy. This very expensive investment, which was approved during a period of economic austerity, was deemed at the time to provide optimum and sufficient protection. In May 1940, however, the German army invaded Belgium, simply doing an end run around the Maginot Line via the northwest, crossed the Ardennes and defeated a surprised and disorganized French army in only one month. When it was conceived in the 1920s, the risk the Maginot Line was designed to counter was that of an infantry battle in Alsace-Lorraine, similar to what occurred in World War I. When the line was completed some fifteen years later, it was no longer suited to the strategy the Germans actually employed.

The case of the Maginot Line has similarities with the case of climate change. The world has never had to face such rapid warming and the study of past events, although necessary, will not be sufficient because we have to expect radically new scenarios. It is therefore essential (i) to take the existence of uncertainty into consideration, which makes it difficult to implement adaptation measures, and (ii) to revise our frame of reference, which is based on the climate of the past, to avoid taking maladapted measures. This is particularly true for investments in infrastructure, the cost and useful life of which make them sensitive to climate fluctuations and the risk of maladaptation.

Other approaches to prioritization

Once the "no regrets" measures have been put in place and the stakes of maladaptive measures have been correctly understood, we must still identify and prioritize additional adaptation measures taking the vulnerability of the territory into consideration. Two approaches are possible:

- The first is based on minimizing future economic costs estimated as a function of future vulnerability, among other things, and the adaptation measures adopted;
- The second is more pragmatic and takes into consideration the analysis of current vulnerability and learning from experience.

The first is based an economic approach via a cost-benefit analysis of the concrete measures being considered. This method has certain limits linked to the hypotheses to be taken into consideration: the risk aversion of current and future generations, the rate of inflation with regard to the financial aspects, future climatic conditions etc. Frequently, and in particular with regard to the question of the adaptation of extreme events, the results of these analyses differ significantly depending on the underlying hypotheses used.

The second method limits the effects of these underlying hypotheses by an approach that favors the most urgent measures. Preference is given to measures that include adaptation to climatic effects that are already being felt to some extent. For example, if there is a confirmed rise in sea level, preference will be given to the management of coastal areas. Putting this type of proactive adaptation measure in place makes it possible to limit current damage and to begin to acquire know-how that will be useful later on, when more serious rise in sea level materializes (regardless of whether the rise in sea level is more or less than expected).

In both approaches it is important to give preference to flexible measures. The adaptation process must be able to be reviewed and revised as we acquire greater knowledge of the impacts of climate change and as the climate change actually materializes.

Finally, the prioritization of adaptation measures to climate change will also be a question of political priorities, in particular in the case of measures that are not "no regrets" measures. Because these measures may potentially entail very high costs for the society although the climate change in reaction to which they have been implemented may not necessary come to pass, it will be necessary to politically justify their adoption. Other criteria such as fairness, social or political acceptability, the risks assumed (with and without the solution) and environmental effects will play an important role in the prioritization of the adaptation measures. For example, adopting certain high-profile measures such as the protection of a territory or a public asset such as the walled city of Saint-Malo by erecting a dike, although expensive and irreversible, could in practice be preferable to other, less radical measures. In any event, our societies may also not be able to solve the problem of adaptation solely with "no regrets" measures if the most pessimistic scenarios materialize.

B. The role of government

With the aim of promoting proactive adaptation guided by different social agents, both private and public, the public sector has a fundamental role to play. We have mentioned the importance of government in the prioritization of adaptation measures when political decisions are involved. In this section we analyze other aspects of the fight against climate change and, in particular, the implementation of adaptation measures for which the government bears significant responsibility.

First of all, the government has the ability to make consideration of potential adaptation measures mandatory and to involve people and economic entities in the process of the implementation of these measures. The involvement of the different social agents will be fundamental to promote awareness, find appropriate and acceptable adaptation measures and to establish priorities.

Then, both to encourage greenhouse gas emissions reduction and to promote the implementation of adaptation measures to future climate change, it is essential to have relevant climatic information on an adequate scale. To do that, initiatives such as the project entitled "Opening access to regionalized French climate scenarios for the impact and adaptation of our societies and environments" (DRIAS) financed by the Management and Impacts of Climate Change (GICC) program of the French Ministry of the Ecology, Energy, Sustainable Development and the Oceans (MEEDDM) are of fundamental importance and cannot be carried out without the support of the government. The information on climate change thereby comes down to a genuine "public climate service", which enables parties who lack expertise in climate modeling (research teams, government departments, engineering companies etc.) to use the results of these studies. Right now, this climate information is available, but scattered. Advances in our ability to describe and illustrate the climate and its operational consequences are still necessary, in terms of both an improvement of the processing of the information and its transfer between the scientific community and the professions that will put it into practice.

It is crucial, moreover, to adapt technical regulations to the future climate. Regulation plays a fundamental role in providing incentives for the implementation of adaptation measures. This is true with regard to both spontaneous adaptation, which cannot take place if the existing standards discourage it, and to planned adaptation, which requires a consistent regulatory framework for its development. To establish this appropriate regulatory framework, a great deal of legal work is necessary to ensure its overall consistency.

A country's development planning policies also have a very important role to play in the reduction of greenhouse gas emissions and the adaptation to climate change. These policies must be modernized to take new information on the impacts of climate change into account. A key question that must be answered is whether we have to create new adaptation policies, which can turn out to be complicated, or whether it is more appropriate to incorporate adaptations into the existing policies. In all cases, adaptation remains a cross-disciplinary subject that impacts numerous policy sectors, from development planning development, education and training to health care.

Finally, although the government has a major role to play, the private sector must also take initiatives to improve its resilience to the impacts of climate change.[8] Its capacity for mobilization and entrepreneurial action must not be ignored.

C. Financing adaptation measures

The question of financing plays a part in the prioritization of adaptation measures. Theoretically, priority should be given to the implementation of economically viable adaptation measures. Nevertheless, certain adaptation measures that are priorities from a political standpoint may not be economically viable. That is the case, for example, with the above mentioned improvement of the Saint-Malo dike. For these types of measures, as in the majority of cases, ad hoc financing solutions must be found. Nevertheless, adaptation can frequently act as an additional lever to promote more sustainable development, because this type of measure can be included in projects that have already been planned and justified for other reasons.

However, this additional financing can be difficult or even impossible to raise. A territory may find itself in a situation in which it is faced with extremely high costs and does not have the means to pay them. That is the case of developing countries and especially of the least developed countries. These countries, which have few financial resources, will experience a major part of the undesirable effects of climate change and have particularly pressing adaptation requirements. This brings up another challenge. The developing countries experience the consequences of a phenomenon for which they are not responsible. The challenge here is more one of fairness than a search for potential financing. From this point of view, funds to assist these countries such as the Adaptation Fund created at the 2001 Marrakesh Conference of the parties to the Kyoto Protocol or the newly created Copenhagen Green Climate Fund cited in the 2009 Copenhagen Agreement have been established. These funds manage financial transfers between developed countries and developing countries, transfers which must be intensified to meet the needs of countries such as Tuvalu in the face of the impact of climate change.[9] Finally, in a recent OECD report, Agrawala and Carraro (2010) point out that the greatest challenges are not only the assessment of the adaptation requirements and raising the funds necessary to implement the necessary adaptations, but also the fact that optimum resource distribution channels must be found to ensure that the assistance reaches the most vulnerable populations.

Considerations on the subject of financing adaptation in the developed countries is also under way, both in France and elsewhere. In France, the Office of Energy and the Climate of the Ministry of the Environment has begun drafting a national plan for adaptation to climate change and has formed three working groups, one of which is concerned with financing. Concrete measures are to be proposed in early 2011.

Specific financing requirements can be expected in the infrastructure sector. These measures represent more than 30% of the total costs of adaptation (see Table 3). Financing new infrastructure must also include the additional costs engendered by the adaptation to climate change. By incorporating these measures as early as the design phase of the infrastructure projects, the cost will be much lower than if the adaptation measures must be carried out on existing systems and structures. In this manner, the adaptation can be integrated into existing mechanisms and the sums required can thereby be reduced. Therefore the increased investment costs incurred as a result of the adaptation can be financed by the traditional infrastructure financing mechanisms such as public-private partnerships, privatization of public utilities and third-party investment (see Inset 2). In many cases, public financing will be insufficient and means will have to be found to attract private capital by applying the leveraging effect of the public sector.

[8] A territory, a sector or an economic agent is resilient to climate change if it is capable of responding to it without suffering adverse effects from its consequences and benefiting from the opportunities it presents.

[9] Drouet (2009) discusses this issue and presents a full panorama of the status of adaptation financing in the developing countries.

Box 2 – Financing adaptation: Example of third-party investment to adapt a building to more frequent heat waves

Improved insulation of buildings makes it possible to keep the interior cooler in the summer and warmer in the winter. In response to an increase in the number and intensity of heat waves, one appropriate adaptation measure is the improvement of building insulation. As this measure improves the energy efficiency of the building and reduces its emissions, it can benefit from financing via a mechanism of third-party investment.

In a third-party investment mechanism, the investor invests in the energy rehabilitation of a building it does not own and earns a return on its investment through the energy savings achieved by the occupant (the owner or tenant). Over a contract for n years, the process is as described below:

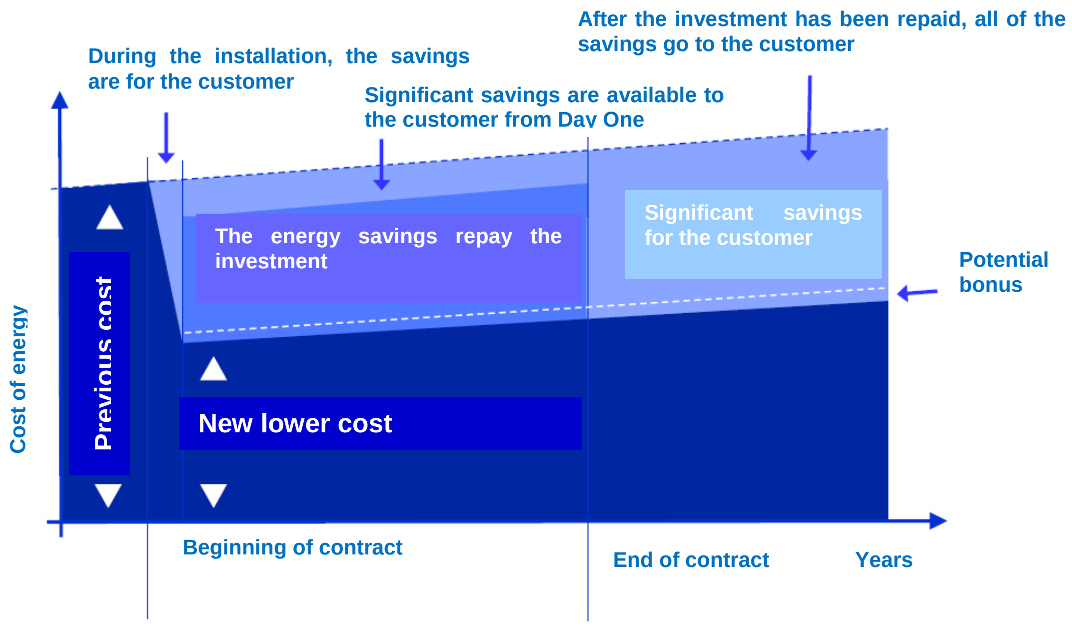
• In Year 0, the building's energy costs are high and the third-party investor makes the investments to improve the energy efficiency of the building, simultaneously making it less vulnerable to heat waves.

• In the Years 1 to n, the building's energy costs have decreased. The owner therefore benefits from savings compared to previous expenses and pays a contractually stipulated amount to the third-party investor. The sum of the amounts paid to the third-party investor represents the return of the investment as well as profits. The contract can stipulate how the benefits related to the energy savings are shared, according to energy costs trends.

• The contract expires in Year n. The owner therefore benefits from much lower energy costs than were incurred in Year 0 (given a constant energy price).

Figure 8 presents a diagram of the third-party investment mechanism on the hypothesis that energy prices rise over time. As such, the total cost of energy increases in relation to the initial situation, and the new "reduced" cost also increases.

Figure 8: Third-party investment mechanism



Source : L Vanstraelen (2008).

CONCLUSIONS

The struggle against climate change consists of two complementary approaches: the mitigation of greenhouse gas emissions and adaptation to the impacts of climate change. It therefore requires the implementation of measures that reduce greenhouse gas emissions as wall as of measures that increase the resilience of natural and socio-economic systems to future climate change.

This second approach, i.e. the adaptation of societies and systems to climate change, must be planned beginning immediately for several reasons. (i) Even if greenhouse gas emissions were reduced to zero, certain impacts of climate change would be inevitable on account of the inertia of the atmospheric concentration of greenhouse gas and the response time of the climate systems. (ii) To do nothing in the face of the climate changes that have already begun would result in unacceptable situations such as the disappearance of certain island countries. Finally, (iii) the costs of climate change will increase over time without the implementation of adaptation measures.

Nevertheless, the implementation of adaptation measures requires careful consideration of their specific characteristics and primarily of their local character. That has consequences on the incentives that must be given to all parties involved as well as on the financing of the measures. It makes it difficult to standardize measures and forces each territory to adapt to its own particular climate impacts using ad hoc approaches. A second problem of the implementation of adaptation policies is the major uncertainty which prevails both with regard to future climatic conditions and their impact on our societies. A third point is that it will be necessary to revise our frames of reference, which are based on historical climate data that influence the vulnerability of existing infrastructure. If they continue to be used, may increase the costs of adaptation when the impacts of climate change materialize, especially for long-lived infrastructure that is difficult to adapt at after construction.

The selection of adaptation measures includes their prioritization. Preference should be given to "no regrets" measures as well as to flexible measures. The measures that could lead to "maladaptation" must be avoided as they ultimately increase the costs of climate change. The government also has a major role to play in the selection of adaptation measures and in providing incentives to adopt proactive adaptation measures. These latter methods also require the availability of information on the pertinent hydro-climatic indicators and their future trends on the regional scale, biophysical impacts, socio-economic vulnerabilities, potential adaptation options and the barriers to implementation. However, an improvement of the spatial resolution of global climate models as well as the increased availability of climate information cannot take place without massive public support. Furthermore, adequate frames of reference can only be created through suitable government regulation, which requires dialogue between legislators and stakeholders.

Currently, the most problematic aspect remains the financing of adaptation measures. On the international scale, mechanisms are being created to assist the least developed countries: however, the question of distribution channels for financial assistance remains a major unresolved point. With regard to financing adaptation in the developed countries, options are being explored by a number of countries including France, where a national plan for adaptation to climate change is being prepared and is scheduled for completion in 2011. The infrastructure sector represents a particular challenge in this context on account of the long life of infrastructure projects. It accounts for a major share of the total estimated costs of adaptation. Existing infrastructure must be studied on a case-by-case basis. However, it is necessary to incorporate incentives for adaptation into financing for new projects immediately. Public investment will not be sufficient, and it will be necessary to find mechanisms to attract private financing.

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