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INFRASTRUCTURES IN THE FACE OF CLIMATE CHANGE:

WHAT IMPLICATIONS FOR LONG-TERM INVESTORS?

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Both the omnipresence of infrastructures throughout the world and the creation of new infrastructures – particularly in developing countries – raise the question of the role they play in the fight against climate change. Infrastructures can serve a double purpose in the face of climate change: "green infrastructures" can help reduce climate change by limiting the greenhouse gas emissions they produce, while "adapted infrastructures" contribute to the adaptation of a region to the climate of the future. They can also attenuate the vulnerability of developing countries, which are the most affected by climate change today.

The construction of both green and adapted infrastructures is intrinsically linked to current public policies. However, the latest climate negotiations held in December 2009 in Copenhagen also emphasised the central role of private investors in financing these infrastructures. Long-term investors, i.e. institutional investors such as pension funds, insurance funds, sovereign wealth funds and other investors that will be conveying massive financial flows over the next few decades, are therefore especially in demand.

In the wake of the recent financial crisis and the context of a global economic downturn, these bodies are now showing interest in infrastructures as an alternative investment providing stable revenue in the long term. However, climate change and its effects on infrastructures and their operation are now a threat to the continuity of these financial revenues.

To optimise the management of risks linked to climate change, long-term investors can play on the choice of infrastructures. They can choose to finance infrastructures that meet location, construction and operation criteria relative to *greenhouse gas emissions reduction* or climate change *adaptation*. These two levers, while distinct, are indispensable and complementary ways of limiting the effects of climate change on investors' revenues. A proactive strategy of integrating climate risk can be enhanced, in most cases, by taking advantage of public regulations limiting greenhouse gas emissions. In addition, this approach can be an asset in terms of image.

However, adopting such a strategy carries risks relating to the use of new technologies and the instability of the regulatory environment. In the event that public authorities wished to mobilise private investors and channel their investment flows towards infrastructures suited to the new climate situation, it might well be in their interest to take on some of the risks by introducing appropriate public guarantees, therefore leveraging private funds.

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The author assumes full responsibility for any errors or omissions.

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INTRODUCTION

The current state of climate negotiations and the growing number of individual initiatives testify to the fact that the impact of climate change has become a reality that must be taken into account by every player in the economy. Catastrophic weather events (storms, hurricanes) and the changes in average weather conditions (temperature, etc.) are already disrupting human activities and foreshadowing the damage to come.

In order to limit as well as cope with this damage, the Copenhagen Accord calls upon the industrialised countries to contribute 30 billion euro in short-term funding between 2010 and 2012, and up to 100 billion euro per year by 2020 to finance climate change mitigation and adaptation in developing countries. The Accord stipulates that medium-term funding will be provided by various public and private sources. Institutional investors, particularly pension funds, sovereign wealth funds, insurance companies, development banks and foundations, occupy a prominent place among the players sought out for their ability to make massive investments both in the short and long term.

Although an increasing number of short- and long-term investors are now accustomed to including non-financial criteria in their equity and bond investment strategies, such criteria are still largely absent from the process of selecting long-term physical assets such as infrastructures. Because infrastructures are characterised by their long lives, they are at the same time particularly vulnerable to climate change and will be the most directly affected – physically and financially – by the impact of these changes in the decades to come.

To answer the questions of long-term investors about integrating the climate issue into their infrastructure investments, this report proposes to present an overview of the climate challenges they are facing today. It will attempt to show to what extent the inclusion of these environmental criteria in deciding which infrastructures to finance has become part and parcel of ensuring the security and profitability of investment portfolios.

In Part I, we will see how the climate threat weighs on long-term investors and the continuity of their revenue from infrastructure investments. In Part II, we will present the two new tools available to them: restrictions on the greenhouse gas emissions of their projects and project adaptation to climate change. We will also look at the role of these two types of actions in investment decision-making. Part III will show the importance of a suitable, effective regulatory framework and cooperation between the public and private sectors in inducing long-term institutional investors to include these parameters in their investment strategies. Finally, in Part IV, the case study on developing countries will demonstrate that the financial needs of these regions can be turned into climate initiatives and business opportunities.

I. INFRASTRUCTURE INVESTMENT: ADDITIONAL RISKS RELATED TO CLIMATE CHANGE

By investing in infrastructure, investors become the owners of an asset that provides recurrent, lasting returns, provided they can predict the characteristics of the investment over the long term. Long-term institutional investors, capable of anticipating the risks related to these investments, are nevertheless confronted with the implications of climate change for their infrastructure assets.

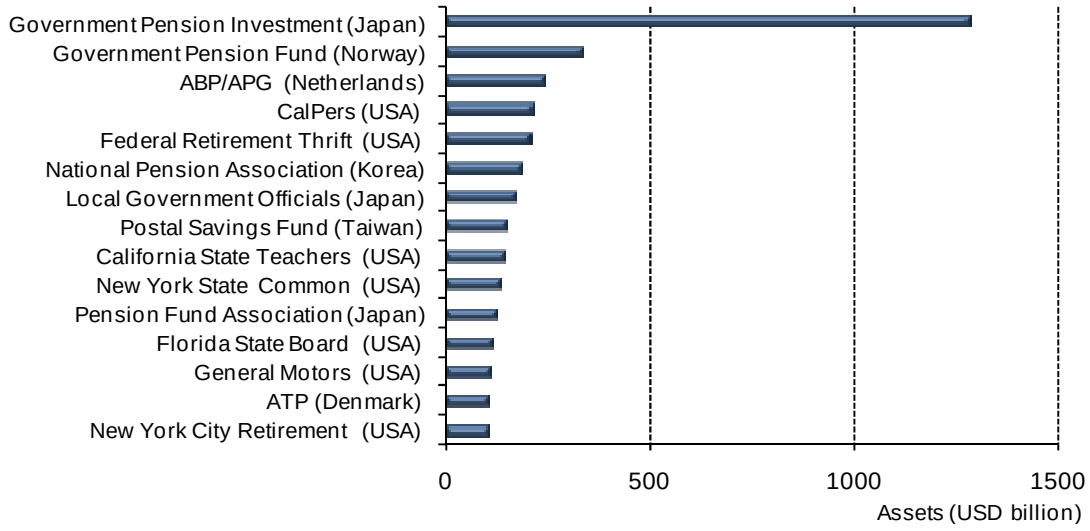
A. Long-term institutional investors: the search for investment stability over time

Long-term investment: the area of choice for institutional investors

The long-term investors we will be looking at here are institutional investors operating in an investment time frame of 20 to 30 years. As institutional investors, they are responsible for sizeable flows in financial markets. However, unlike investment banks or major short-term investment funds, they choose to make investments in the long-term on their own behalf or for their clients. There are several types of investors in this category:

- Organisations such as pension funds or insurance funds that collect the savings of their clients. In 2009, pension funds handled a total of more than 12 trillion dollars. These funds, whether public or private, are made up of employee contributions, which are then invested in a portfolio of financial assets comprising equity, bonds and increasingly alternative investments such as real estate, infrastructures and raw materials. The purpose of these funds is to provide a steady income to employees upon their retirement. Figure 1 shows the ten largest pension funds in 2005. The first is the Japanese government pension fund, which in 2009 represented more than 1.2 trillion dollars; 81% of the fund is allocated to long term investment in equity (11%) and long-term domestic bonds (70%), 18% to international assets and 1% to short-term assets.[1]

Figure 1 – The 10 largest pension funds at 1 January 2009



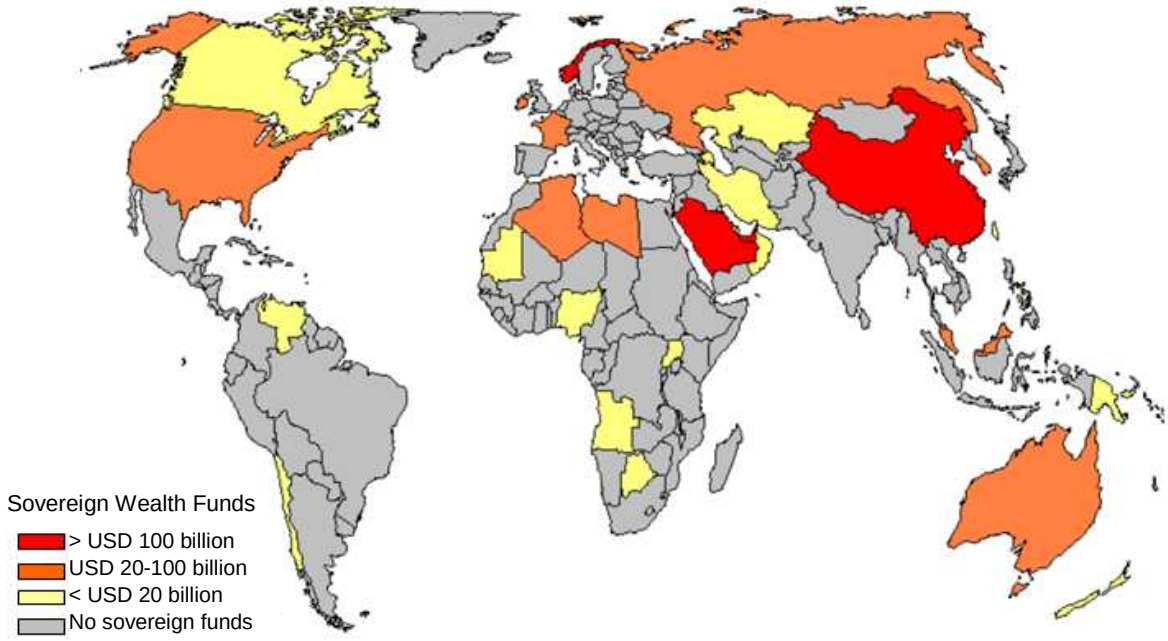
Source: Pensions & Investments/Watson Wyatt Global 300 survey 2008.

- Sovereign wealth funds. These funds have the same type of portfolio (equity, bonds and alternative investments) but they comprise revenues that governments have decided to isolate from the ordinary process of budget allocation and asset management. Part of the major

[1] Source: GPIF Government Pension Investment Fund, Japan, Activities report for the 2nd Quarter 2009.

sovereign funds, such as those in the Middle East or Russia, has come mainly from the sale of natural resources, especially oil. *China Investment Corporation* funds are derived from the revenues resulting from official exchange transactions. Others, such as *Temasek Holdings* in Singapore, were created to reinvest budget surpluses and proceeds from privatisations. Many of these funds have explicitly adopted an investment strategy *to benefit future generations*, which means particularly long investment time frames. Today, sovereign wealth funds represent a total of 3.75 trillion dollars, an amount that, according to estimates by Morgan Stanley and Deutsche Bank, could reach 10 to 12 trillion dollars by 2015. Present in numerous countries across the globe, including developing nations (Figure 2), these funds are often viewed as domestic and international investment funds of national savings.

Figure 2 – Map of sovereign wealth funds throughout the world



Source: CDC Climat Recherche based on SWF Institute data, 2009.

- Other types of investments can also be categorised as long-term institutional investors in view of the length of their investments and the amounts they contribute, such as development banks, foundations and investment banks with long-term commitments.

A portfolio structure emphasising steady returns

Long-term investors usually decide to invest their capital based on the degree of risk involved and the expected profit from the investment. Given the source of their funds – notably pension funds – they are also particularly concerned about the regular recurrence of their revenues over a long period of time.

While long-term investors have traditionally focused on domestic and international investments in equity and bonds, they are now seeking to diversify their portfolios to ensure better risk coverage and revenue continuity. In a difficult economic and financial context, these investors are turning towards alternative investments that promise stable revenues from their portfolios, particularly in real estate, infrastructures and private equity. Although such investments generally account for only 3% to 5% of their total assets, they play a major role in diversification strategies and represent sizeable amounts in the global markets involved. Taking pension funds as a whole, for example, the allocation of 3% of their resources to alternative assets (real estate, infrastructures, private equity) is equivalent to investing about 360 billion dollars in these markets.

B. *Infrastructures: a long-term asset that meets this objective*

Infrastructures: definition

Infrastructures are defined as the set of systems, services and installations needed to ensure the smooth operation of a community or society. They constitute urban and community areas across the world. According to OECD, they are a "means to ensure the provision of goods and services that contribute to prosperity and economic growth as well as quality of life." They generally have a lifetime of several decades, ranging from 20 to more than 100 years. Chart 1 presents a few examples of infrastructures and their average life according to the International Energy Agency[2] (IEA).

Chart 1 – Examples of infrastructure life spans

	Average lifespan (years)
Urban infrastructures (roads, etc.)	120
Hydropower production infrastructure	90
Real estate	80
Coal-fired energy production infrastructure	50
Electric power transmission and distribution infrastructure	45
Nuclear power production infrastructure	45
Pipelines	40
Windmills	20
Photovoltaic panels	20

Source: CDC Climat Recherche based on 2008 IEA/OECD data.

Infrastructure investments are commonly divided into two categories (Chart 2):

- Firstly, they include so-called *economic* infrastructures, which contribute to the *economic* activity of a region. This category comprises transport networks (railway networks, roads, toll roads, airports, bridges, ports, etc.), communication networks and certain urban services (water supply, energy production and distribution networks). In many cases, users pay for these urban services, payment which serves as the basis for remunerating the initial investor.
- On the other hand, so-called *social* infrastructures are designed to meet the basic needs of the inhabitants of a region. They include facilities dedicated to education, health (water and waste treatment, hospitals), housing, security (prisons, military and police centres) and cultural and leisure activities (parks, etc.). These services are often publicly financed. Today, these infrastructures are sometimes described as social and *environmental*. This category may also include protective infrastructures designed to attenuate the impacts of climatic events, which we will discuss later on in this document.

[2] International Energy Agency, World Energy Outlook 2009.

Chart 2 – Types of infrastructures by sector

"ECONOMIC" INFRASTRUCTURES					
Transport/ Logistics	**Roads** **Railway networks**	**Airports**	**Ports** **Ferries**	**Pipelines**	**Bridges** **Tunnels**
Energy and Community services (utilities)	**Energy production**	**Natural Gas** (distribution / storage)		**Electricity** (production/ distribution)	**Water** (distribution)
Communications	**Cable networks**	**Satellites**		**Transmission / Broadcasting** (wireless network, radio waves, etc.)	
"SOCIAL" INFRASTUCTURES					
Health care infrastructures (hospital, etc.)	**Waste** (treatment)	**Water** (treatment/ distribution)	**Housing**	**Leasure activities** **Education**	**Penitentiary infrastructures**

Sources: CDC Climat Recherche based on RREEF Infrastructure.

Infrastructures: risk- return profile

Due to their lengthy lives (see Chart 1), infrastructures are an asset class that ensures the investor steady, predictable revenues over a period of at least 10 years and often more than 30 years. The risk-return profile of infrastructure investments depends in large part, however, on the maturity of the infrastructure at the time of investment. For example, the project development phase presents – among other risks – construction risks which may be covered by the public sector when it wants to attract investors at the outset of a project. However, investing in this phase guarantees the investor revenue from the infrastructure. On the other hand, the operating phase presents operating risks but it is synonymous with immediate returns that will be predictable and recurrent over time.

Investment in a new infrastructure may be characterised by an initial phase of lower profitability, and therefore less rapid return on investment than other types of assets. However, the investment will prove more advantageous in the longer term: according to Inderst (2009)., with good risk management, it will ensure a higher rate of return than any other investment – supposing the investor does not engage in early withdrawal of the amount invested.[3] Although it is difficult to generalise on the topic of risk vs. return estimates in the short and long- term for investors as a whole, it appears to be advantageous for long-term institutional investors to invest in these assets over the long term and strive to control the risks.[4]

Infrastructures and long-term institutional investors

Traditionally funded by public sector capital, infrastructure financing by private sector players – including institutional investors – began in the late 1980s. The World Bank estimates that until recently, the public sector financed 70% of infrastructures compared with 20%-25% by the private sector and 5%-10% of development aid (PPI Database). Since the end of the 1980s, the trend has shifted and the gap between public and private financing has narrowed.

[3] In the short term, private equity investments generally generate greater profitability but also carry greater risks. For further information on this topic, see RREEF (2007).
[4] For examples of risk- return estimates, see Inderst, G. (2009)

According to RREEF[5], today's worldwide infrastructure market – made up of new infrastructure assets (construction) and existing ones (operating infrastructures) – is estimated at between 17 and 23 trillion dollars annually worldwide, including 4 to 6 trillion dollars in Europe[6]. This market is considered a market with a stable and growing demand[7] flow, stimulated by ever-increasing global wealth, which has tripled since 1970. It is also characterised by the amounts invested in individual assets. Indeed, it is not unusual to see assets valued at more than 1 billion dollars acquired either by major investors or groups of investors. These assets are consequently particularly well suited to institutional investors with massive amounts of resources to allocate.

Although figures for the total amount of infrastructure investments by long-term institutional investors are not available, an increase in the number of initiatives by these major investors has been observed. In particular, several recent initiatives by pension funds can be noted: in 2008, the Californian CalPERS pension fund decided to allocate 7.2 billion dollars to infrastructure financing, with a planned return on investment over 5 years. Similarly, the Dutch pension fund investment body ABP (APG) decided to allocate 2% of its resources to infrastructures over the period 2007-2009, i.e. an amount of approximately 6 billion Euros. The Long-Term Investors' Club (Box 1) plans to invest a total of 3 trillion dollars, a portion of which will be allocated to financing infrastructures included in actions to combat climate change.

[5] The section in charge of alternative investments in the asset management department of Deutsche Bank, which manages three types of assets: real estate, infrastructures and private equity.

[6] The RREEF estimate of the global amount is an extrapolation based on the estimate for Europe weighted by GDP.

[7] Inderst, G. (2009).

Box 1 – The Long-Term Investors' Club

With the desire to invest in infrastructure projects to foster economic recovery, the Long-Term Investors' Club has been gathering together long-term investors from around the world since April 2009. It is currently starting up two funds dedicated to infrastructure – InfraMed and Marguerite – with members as shown in Figure 3. The Long-Term Investors' Club Charter includes commitments to social and environmental responsibility and economic support. In other words, one of the Club's objectives is to invest in "green" infrastructures, i.e. which produce low GHG emissions.

Figure 3 – Long-Term Investors' Club funds dedicated to infrastructure

Long-Term Investors' Club	
Founding members	
Caisse des Dépôts	France
Cassa depositi e prestiti	Italy
KfW	Germany
BEI	EU
Other members	
CDB	China
Caisse de Dépôt et de Gestion	Morocco
VEB	Russia
ICD	Dubai
Mubadala	Abu Dhabi
Omer	Canada

European Commission						
Fonds Marguerite (Fonds européen 2020)						
Objectif : € 1,5 milliards en fonds propres						
Facilités de crédit (€ 5 Mds)						
Sponsors						
Caisse des Dépôts	ICO	PKO	Cassa depositi e prestiti	KfW	BEI	
France	Espagne	Pologne	Italie	Allemagne	UE	
Energy, climate change and infrastructures						

Union for the Mediterranean				
InfraMed Fund				
Objective: € 400 million - € 1 billion in equity				
Credit facilities				
Sponsors		Associate sponsors		
Caisse des Dépôts	Cassa depositi e prestiti	Caisse de Dépôt et de Gestion	EFG Hermes	
France	Italy	Morocco	Egypt	
Urban, Energy and Transport infrastructures in Southern and Eastern regions of the Mediterranean				

Launched on 3rd December 2009, the *Marguerite* fund aims to invest 1.5 billion euro in equity in major infrastructure projects in Europe (trans-European transport and energy networks and the renewable energy sector) over periods of fifteen to twenty years. At present, the fund includes six long-term investors and may be joined by other similar investors in the future.

Launched on 30th April 2009, the *InfraMed* fund aims to invest between 400 million and 1 billion euro in equity in urban, energy and transport infrastructures in the southern and eastern Mediterranean regions. Operating within the scope of the Union for the Mediterranean, to date the fund has two main sponsors (Caisse des Dépôts and Cassa depositi e prestiti) and two associate sponsors (the Egyptian investment bank EFG Hermes and Morocco's Caisse de Dépôts et de Gestion).

Source: CDC Climat Recherche based on LTIC.

(updated 15th April 2010)

C. The security of infrastructure investments threatened by climate change

Because infrastructures are used over a long period of time, infrastructures are sensitive not only to the existing climate at the time of their construction, but also to climate variations during the decades of their use. The prospect of significant climate change will require project managers to pay special attention to this parameter. Climate change gradually generates new risks and opportunities; failure to understand or manage them properly could adversely affect the staying power of infrastructure investors.

Observing climate change in order to anticipate risks and opportunities

For the last few decades, increasing changes have been observed in climate as well as in the frequency and intensity of extreme weather events: temperature and rainfall fluctuations exceeding normal historical levels, rising sea level and increasingly frequent floods, droughts and storms are some of the current consequences of climate change that are very likely to multiply in the coming years. These changes are likely to accelerate climate-based physical and economic impacts across the world.

Box 2 – GHG emissions are disrupting the climate

According to the experts on the Intergovernmental Panel on Climate Change (IPCC), the climate change now under way is due to the increased concentration of six greenhouse gases (GHG) in the atmosphere: carbon dioxide (CO_2), methane (CH_4), nitrous oxide (N_2O) and fluorinated gases (HFC, PFC, SF_6). The rising greenhouse effect resulting from emissions of these gases on a global scale is altering our climate. According to the IPCC, the average global temperature could increase by between +2°C and +6°C by 2100. This wide range is due to two ty pes of uncertainty: (1) the first is inherent in our understanding of how the earthly climate machine works, as there is a certain amount of uncertainty in the models used to forecast how the atmosphere responds to GHG concentration; (2) the other is inherent in our ability to forecast the future: we do not know today what the level of manmade emissions will be in 2100; it will depend on our current and future policies and economic choices.

According to the Intergovernmental Panel on Climate Change (IPCC), these impacts will be both positive and negative, some of them offering opportunities for certain economic players. For example, more sunshine will enable increased production of solar-based energy. However, according to these same estimates, the total sum of these impacts is negative, implying more risks than opportunities for investors. In certain regions of Asia, for example, cyclones and heat waves are likely to increase in frequency and intensity.

Like any economic players, long-term investors can therefore take advantage of the opportunities related to climate change, but it will also be in their interest to protect themselves against the risks that arise. It would appear more relevant than ever today to anticipate climate change to avoid being subjected to them. A detailed analysis of the impact of climate change on infrastructures can therefore anticipate the underlying economic and financial opportunities and risks so their potential impact can be included in decision-making.

Infrastructures: from physical impacts to financial consequences

In general, it is predicted that infrastructures will be more vulnerable to the frequency of extreme weather events (e.g. cyclones) than to changing weather trends (e.g. temperature increases). The impacts will affect infrastructures in two ways:

- Firstly, they will affect the use of infrastructures (operating consequences): climate change could make operations more problematic or easier. For example, in the case of a rail transport infrastructures, higher temperatures could dilate or distort the rails, leading to shifting tracks (physical impact). This would have repercussions on the operation of the transport infrastructure, such as lower operating speed or even total service shutdown (operating impact).[8]
- Secondly, they will affect all activities for which the infrastructures were built (indirect consequences). For example, the failure of electric power or communication networks could shut down a business temporarily or permanently, putting the employees out of work. As all economic and social activity depends on infrastructures – water, waste, transport, energy and industry – the

[8] Cochran, I. (2009).

whole economy could suffer as a result. On the other hand, such physical failures could offer an opportunity to develop digital communication infrastructures and more broadly new information and communication technologies (NICT).

Let us take a closer look at the negative operating consequences and their direct effect on investors. In the event an infrastructure is destroyed by an extreme weather event (storm, etc.) or the use of an infrastructure is compromised by a climate change or impact, the financial returns from the infrastructure would immediately disappear. Thus, the income stream generated by infrastructure investments – in other words, the very reason why investors are interested in this type of asset – would be altered. More generally, the risk of physical and economic impacts linked to climate change can be seen as an overall increase in a number of existing risks. For example:

- It could elevate the environmental risk, i.e. the danger of an extreme weather event occurring. This risk is especially high insofar as the consequences of climate change are likely to vary significantly from one region to another and it is difficult today to assess climate change at the local level.
- It could engender additional operational risks: for example, if river resources required for operating a nuclear power plant dry up or increase in water temperature, it could bring about failures inside the plant and lead to an interruption of the energy supply.
- It could affect the risk market: take a road linking two companies, for example. In the event that one of the companies is forced to shut down due to the climate (i.e. its production depends on the climate or on natural resources), the flow of road users will drop sharply.
- It could give rise to a new geopolitical risk resulting from climate-related migration of populations subject to climate change. For example, a decrease in water resources in Africa could give rise to new regional tensions, and hence a higher risk of conflict.

Long-term investments in infrastructures are therefore at risk due to climate change. To cope with those climate risks, long-term investors can resort to insurance. This solution, although necessary, is not sufficient.

Insurance coverage of climate risk: an inadequate solution

Today, insurance makes it possible to cope with a number of risks, two of which are directly linked to the physical impact of climate change. The first is the occurrence of catastrophes of low or medium severity that affect activities in a limited geographical area. The second is the risk related to high-intensity catastrophes such as floods or storms with a far greater impact in terms of economic and human costs over a longer period of time and a wider scope. This second type of impact corresponds to extreme weather events, which are likely to increase along with changes in the climate.

Given the expected climate change, it is easy to imagine that the demand for insurance will rise accordingly. The potential increase in demand, notably on the part of investors, is driving insurance companies to seek innovative ways to meet the challenge, despite major uncertainties as to the exact damage resulting from climate change: recourse to financial markets through bonds or derivatives specifically dedicated to natural catastrophes (e.g. climate derivatives, cat bonds,[9] etc.). In spite of these financial innovations, insurance companies are currently unable to cover climate risk entirely for several reasons. The following list, while not exhaustive, illustrates the need to supplement insurance systems with other means:

1. The uncertainties linked to climate change make it difficult to generate the models currently used by insurance companies for business planning. These models, which are usually based on

[9] A Cat Bond ("Catastrophe Bond"") is a bond with a return that is determined by the occurrence of a natural catastrophe. These bonds are typically used by insurance companies as reinsurance against catastrophic risks.

historical data, are indeed ill suited to the new, uncertain nature of the impacts caused by climate change.

2. Because environmental risks differ from one place to another on a local scale, it is difficult for investors to group together geographically to cover them. Unlike traditional financial risks, which are uniform at the regional level and can be grouped together geographically, environmental risks – even within a limited geographical scope – are of different natures and degrees of uncertainty.
3. As private players, insurance companies adopt a financial approach to their business. Yet, as climate change becomes more pronounced, climate risks will rise and insurance companies may choose not to cover certain infrastructures considered too high-risk – e.g. located too close to a coastline.
4. Finally, if investors fail to anticipate climate change, they will have to assume a significant financial burden, even if their infrastructures are insured. Indeed, (1) premiums on insurable infrastructures will go up as climate risks increase, implying growing insurance costs over time and (2) non-insurable infrastructures may be subjected to the impact of climate change that result in immediate loss of capital.

Faced with the considerable economic impact of climate change and the inadequacy of the insurance sector to cope with it, a proactive approach seems to offer investors a way of responding to the climate issue.

II. PROACTIVE MANAGEMENT OF THE CLIMATE FACTOR

Few long-term investors today have a consistent strategy for integrating the risks linked to climate change into their infrastructure investments. Yet, if no effective measures are taken, infrastructure malfunctioning caused by climate change could result in considerable financial losses.

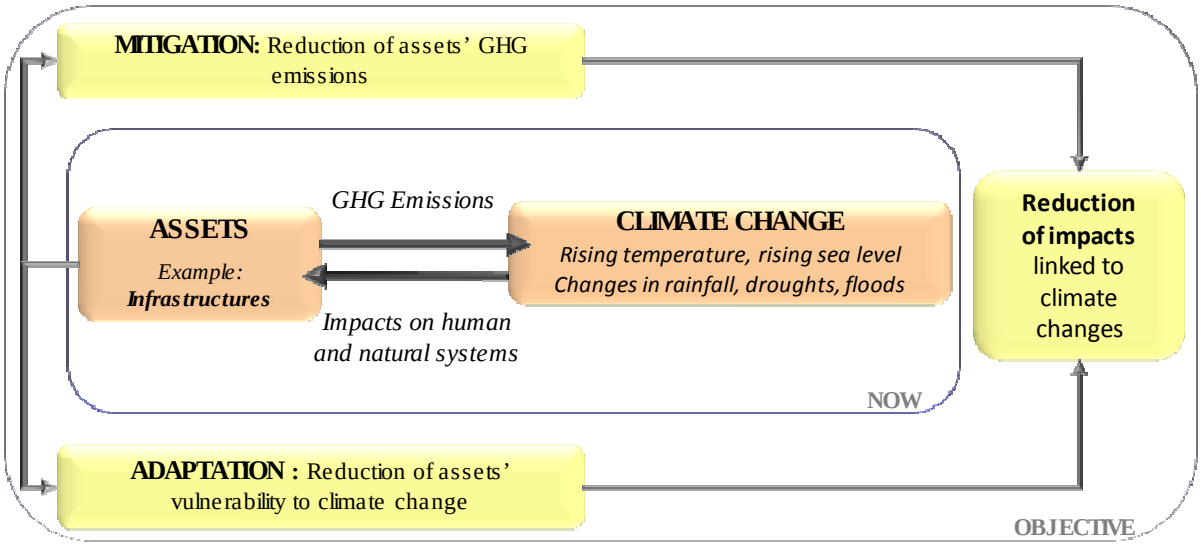
A. A twofold action for investors: choosing infrastructures that are "green" and adapted

Several solutions are available to long-term investors to reduce the impact that climate change will have on their infrastructure assets (Figure 4).

Firstly, they can choose to *mitigate* climate change by investing in assets that emit low levels of GHG, thereby diminishing the risk of negative impacts linked to the climate. More specifically, in the case of infrastructure financing, they can choose to invest in infrastructures that lead to little or no greenhouse gas emissions, known as *green* infrastructures. This type of action is called climate change *mitigation*.

Secondly, they can *anticipate* inevitable climate change by adapting assets today to the climate likely to occur in the coming years. Indeed, it is possible today to anticipate and reduce some of the damage that the climate will cause to infrastructures. This type of action is called climate change *adaptation*.

Figure 4 – Infrastructures in the face of climate challenges



Source: CDC Climat Recherche.

Mitigation and adaptation actions complement each other. A green infrastructure built in a coastal area may lose all its advantages in the event of a rise in sea level – the infrastructure would help reduce GHG emissions but would not be adapted to the change in its environment. On the other hand, introducing solar panels in a place where the amount of sunshine is increasing due to climate change is an example of taking advantage of the future climate – hence adapting – while producing renewable energy.

In the investor's individual cost-benefit analysis of a project, mitigation and adaptation measures are assessed in different ways. In both cases, the investor assumes the costs linked to the project. However, in terms of benefits, adaptation brings a direct, tangible benefit (i.e. a less vulnerable infrastructure), whereas mitigation benefits society as a whole and the individual investor only very marginally. In economic terms, adaptation therefore has the characteristics of an individual good, whereas mitigation could be considered as a common good. Without regulations inciting investors to internalise the extreme costs arising from the projects they finance, it could be reasonably assumed that individual long-term investors would find it more interesting to adapt infrastructure rather than to build green infrastructure.

High potential for emission reduction in infrastructures

In general, we can distinguish four methods for reducing the emissions of an infrastructure:

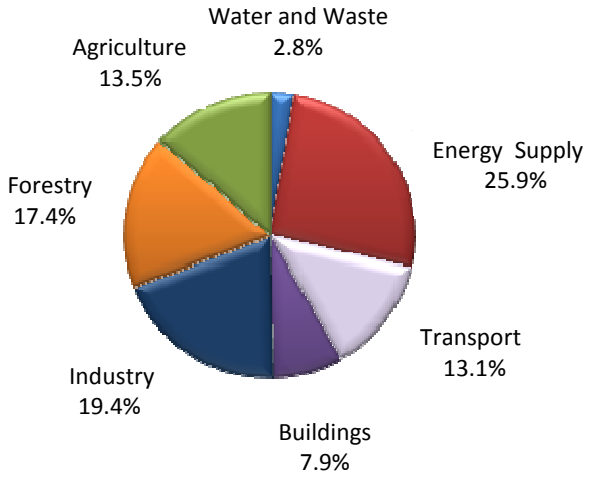
- Reducing emissions through the choice of the type of infrastructure to finance. For example, the construction of a public transport infrastructure rather than a motorway;
- Reducing emissions through the choice of infrastructure location. For example, the construction of a building in a place served by public transport to limit the emissions related to the commuting of employees working in the building;
- Reducing emissions through the materials and equipment used to build or renovate the infrastructure. For example, using effective insulating materials or installing an energy-saving boiler in a building;
- Reducing emissions through the use of the infrastructure. For example, installing regulating systems to optimise the use of heating or lighting.

More specifically, different methodologies are used to measure both GHG emissions and GHG emissions reductions. Analysing the emissions linked to each phase of the infrastructure life cycle leads to separating emissions due to infrastructure construction, use and demolition. Another methodology is to use three scopes analysing the direct and indirect emissions according to a classification proposed by the

GHG Protocol[10]. When applied to infrastructures, this methodology allows us to measure the emissions linked to the activity or use of the infrastructure (Scope 1), those linked to the production of the energy used during the activity/operation of the infrastructure (Scope 2) and the emissions produced indirectly by the infrastructure, including emissions resulting from the production of equipment used in the construction and other emissions related to the use of the infrastructure such as the transport of users and employees (Scope 3). Other methodologies exist, some of which can give rise to hybrid or combined methods.

In an attempt to apply this methodology to infrastructures globally – measuring the emissions linked (1) to the construction and demolition of an infrastructure, (2) to the production of the energy required for infrastructure operation, and (3) to the use of the infrastructures (e.g. cars using a road or the emissions resulting from the boiler in a building) –, we can estimate the emissions linked to infrastructures and their use at approximately two-thirds of total global emissions. Figure 5**Erreur ! Référence non valide pour un signet.** shows the worldwide breakdown of emissions by sector in 2004. It should be noted that the building, energy, water, transport and industry sectors account for nearly 70% of worldwide emissions.

Figure 5 – Global GHG emissions in 2004 by sector



Source: Third Working Group, Fourth Report of the IPCC, 2007; World Bank.

In the short term, this implies that (i) corrective actions must be carried out on existing infrastructures on a global scale and particularly in developing countries; (ii) anticipatory actions and new standards must be integrated into the construction of new infrastructures, both in developed and developing countries.

Chart 3 shows the measures recommended by the United Nations Framework Convention on Climate Change (UNFCCC) to reduce the emissions of both new and existing infrastructures and infrastructure equipment. It indicates the potential GHG emissions reduction by infrastructure sector – i.e. a total of 12 to 20 Gt CO_2eq per year compared to current levels. Such reductions would make it possible to limit the concentration of GHG in the atmosphere to 450 ppm, which is theoretically compatible with global warming of less than 2°C.

[10] The GHG Protocol was introduced jointly by the World Resources Institute (WRI) and the World Business Council for Sustainable Development (WBCSD) to set guidelines for estimating emissions. http://www.ghgprotocol.org/

Chart 3 – Actions recommended by the UNFCCC to reduce GHG emissions in infrastructures and their equipment and potential emissions reduction estimated by the IPCC

Sector	Recommended action (UNFCCC)	Potential emissions **reduction (Gt CO2eq/an) (IPCC)**
Buildings	Improved efficiency of heating, hot water and lighting systems and of household appliances	Developing countries: 2.7 -3.3 World: 5.3 - 6.7
Industry	Enhanced energy efficiency and installation of carbon capture and storage (CCS) infrastructures	Developing countries: 1.6 - 3.8 World: 2.5 - 5.5
Energy supply	Use of technologies for carbon capture and storage (CCS), renewable energies, nuclear energy and hydropower	Developing countries: 1.3 - 2.7 World: 2.4 – 4.7
Waste	CH_4 capture at waste and wastewater treatment centres for reuse as fuels or as a source of electricity	Developing countries: 0.2 – 0.7 World: 0.4 - 1
Transport	Construction of public transport, production and use of hybrid vehicles	Developing countries: 0.15 World: 1.6 – 2.5
	TOTAL Infrastructures	Developing countries: 5.95 – 10.65 World: 12.2 – 20.4

Source: CDC Climat Recherche based on UNFCCC data.

This chart also shows that, apart from the transport sector, half of the potential for GHG emission reduction in infrastructures concerns infrastructures in developing countries. This observation comes in addition to the fact that 77% of the energy infrastructures that will be necessary in 2030 have not yet been built (Project Catalyst, 2009). Most of these new infrastructures will be built in developing countries. An essential point of GHG emissions reduction on a global scale will therefore be to avoid reproducing the carbon-emitting methods used today to build new infrastructures. This point will be developed further in Part IV.

Adapting infrastructures to the future climate: the challenges

The vulnerability of a region or an activity to the physical impacts of climate change can be defined as the degree to which a system is *capable* or incapable of coping with the harmful effects of climate change, including those of climate variability and extremes[11]. It is distinct from sensitivity, which is the degree to which a system is *affected* positively or negatively by the elements of climate change (including average characteristics, climate variability and the frequency and scope of extremes). Vulnerability depends on the nature, scope and pace of climate change to which the system is exposed, as well as its sensitivity and its ability to adapt in economic, institutional, human and social terms. Lowering vulnerability to climate change through improved adaptation therefore reduces the sensitivity of a region or an activity to the climate variations to come.

The vulnerability of urban and rural areas is a major challenge, as these territories are a decisive factor in most human activities. Furthermore, because most human activities rely on infrastructures, whether economic (energy, transport, etc.) or social (particularly health and education infrastructures), the vulnerability of the economy as a whole is linked to the vulnerability of infrastructures For example, as we saw earlier, damage caused to the transport infrastructures of a given region (transport of people and goods, communication networks, electricity grid) directly affect companies by slowing down or freezing their production. Failure to anticipate such impacts will have an immediate effect on all investors' assets and therefore on their investment return.

[11] IPCC (2007).

The long lives of existing and new infrastructures put them at the core of climate issues. On the one hand, existing infrastructures will have to be renovated to cope with climate change. As for current projects, the rather inflexible nature of their construction implies that they must integrate technical and institutional solutions now in order to avoid damage from climate change or take advantage of its positive consequences. Infrastructures today will namely have to take future climate change into account in terms of their *nature* (resilience and flexibility of the infrastructures in the face of a changing climate, etc.) and their *location* (far from coastal areas, etc.) – criteria that could be incorporated into land use plans. These infrastructures will firstly have to respond to the growing need for essential services related to climate change (access to water, energy, etc.); the operation of these so-called *productive* infrastructures will have to be guaranteed in spite of altered climate conditions. Secondly, in view of their structuring role in urban development, they could take the form of so-called *protective* infrastructures, designed to protect a region (dikes, water retention tanks, etc.) and reduce its vulnerability to climate impacts.

One major difficulty raised by the process of adaptation: climate uncertainty

The uncertainties and lack of precise information on upcoming climate change at the local level raise a number of questions regarding the timing in decision-making for investments in adaptation actions. This issue raises two questions in particular.

The first question is: how can today's infrastructures be properly adapted given the uncertainties about the climate of the future? One of the risks in implementing adaptation actions is indeed the danger of "maladaptation"[12], i.e. adaptation undertaken too radically or hastily that ultimately proves to be poorly adapted to the future climate. "Maladaptation" could indeed produce the opposite of the originally intended result: the initial investment will be raised to compensate for the climate risk, but, because the adaptation measure turns out to not be in adequacy with the climate, the investor will ultimately have to assume the climate risk despite his attempted anticipation. One example of maladaptation is building a dike that turns out to be superfluous because the rise in sea level is not in line with projections.

This question is intrinsically linked to the second, namely: should the investment be made now? Indeed, it is difficult today to predict to what extent the measurements and data on climate can and will be more exact in the coming years. This raises another question: given that we now know there is a climate risk, should we anticipate it and invest today or bet on favourable changes in climate science or emission trajectories within a sufficiently short period of time that we are still able to react? Two solutions recommended in the literature[13] are (1) choosing "no regrets" options, which are adaptation actions that will pay for themselves no matter what happens to the climate and (2) building so-called flexible infrastructures, i.e. infrastructures that can evolve with climate change. For example, we can imagine a dike with a gradual adaptation capacity that could be raised in the future. The cost of a gradual adaptation would then be minimal compared to the initial cost as well as the potential losses resulting from maladaptation at an earlier phase. Other types of actions, such as strengthening cooperation among project players and the gradual introduction of adaptation measures will lead to the adoption of integrated strategies that are often more effective.

While these questions are essential for investors, it is for now difficult to answer them due to the uncertainties inherent in the climate issue. Nevertheless, due to the urgency of the climate situation, these investors are called upon today to take action.

[12] OECD (2009a).
[13] Hallegatte, S. (2009).

B. Implications for infrastructure investment strategies

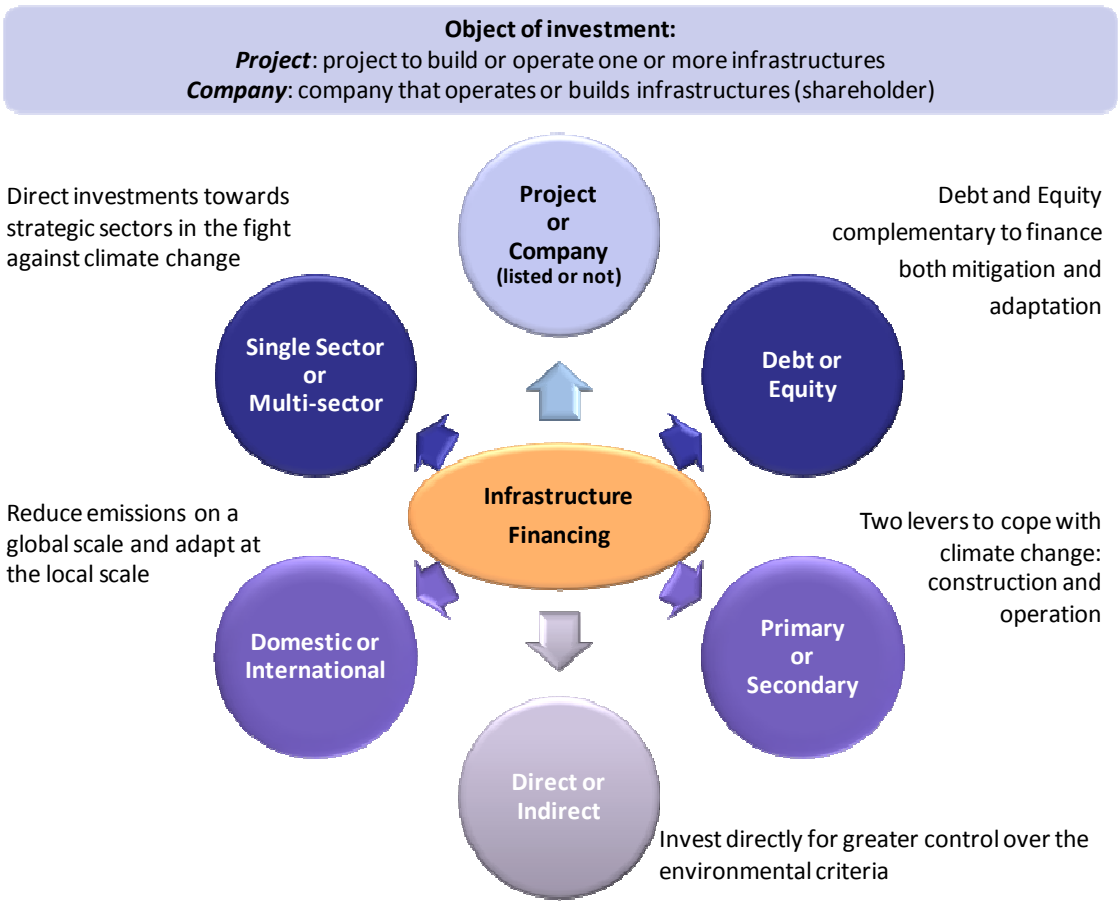
Actions to reduce GHG emissions and adapt to climate change must be integrated into the infrastructure choices of long-term investors on several levels.

The choice of the mode of financing

Beyond the question of timing, an investor's strategy involves several aspects that may include climate parameters (Figure 6). Investors can choose to integrate mitigation and adaptation actions into their strategy in different parts of their investment decision:

- *Long-term debt or equity*? As in any project, the limits of equity financing lie in the fact that it requires a sufficiently high yield to justify the investment. Project financing through equity therefore applies to water or energy supply projects, which offer long-term profitability and are necessary for sustainable land use. Other specific adaptation projects, such as dikes and other protective infrastructures, may not fulfil this criterion. The social value of these projects is very high, but their financial value is low. In that case, financing through long-term debt is more suitable than financing through equity. Equity and debt are therefore two complementary levers to be used by long-term investors to reduce simultaneously GHG emissions and regional vulnerability.
- *Primary or secondary financing*? Primary financing (construction phase) implies the possibility of directly including GHG emissions reduction and adaptation to climate change among project development criteria, hence giving the investor the guarantee that these criteria will be taken into account. The construction phase carries greater risk for financiers, however, which might dissuade them from investing. In that case, they could opt for secondary financing (existing, operational infrastructure), which is more complex as regards the integration of climate-related requirements, since it involves "supplementing" an existing infrastructure so that it will emit less GHG or be better adapted to the climate of the future. This type of financing is more common because it diminishes the risk for the investor. Investors' strategies may therefore include arbitration between introducing environmental measures and the extent of the traditional risks of project financing.
- *Domestic or international investment*? The investor's geographical positioning is involved in two ways. In the case of mitigation actions, emission reductions have an impact on a global scale: the effect on climate change will be the same regardless of the geographical location of the infrastructure. In the case of adaptation actions, the impacts of climate change vary from one place to another, and investors' choices are intrinsically related to their overall strategy. They may choose to invest in their own countries to reduce their vulnerability or opt for an international adaptation action.
- *Single- or multi-sector investment*? Like any ordinary investment, investors may choose to direct their investments to one sector rather than another if they think it corresponds more fully to their overall strategy in the face of climate change. They can also decide to direct their financing towards actions aiming at adaptation or mitigation only.
- *Direct or indirect financing?* Direct financing (without a financial intermediary) in an infrastructure gives investors greater control over the actual inclusion of climate criteria.
- *Project financing or investment in a company?* The amount of investor control over the aim of their investment varies depending on the type of investment (project or stake in a company); their ability to integrate or demand environmental criteria will vary as a result.

Figure 6 – Various options for integrating climate criteria in infrastructure investments



Source: CDC Climat Recherche based on OECD.

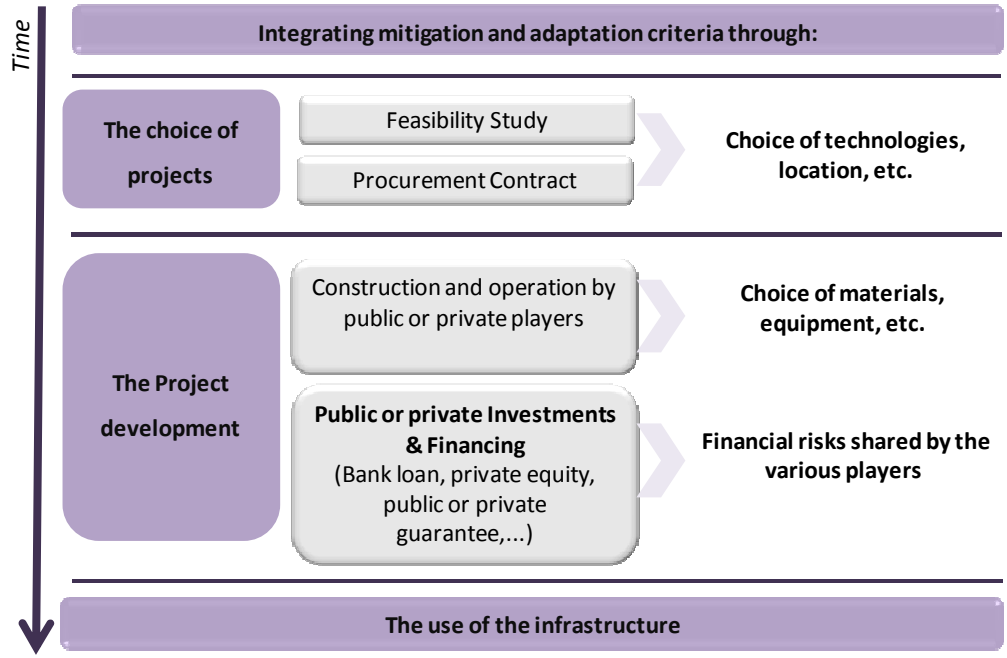
Orienting the environmental characteristics of financed projects

According to an OECD study on infrastructure investments by pension funds[14], long-term institutional investors would prefer to invest (1) in direct equity in projects (project financing) or (2) in infrastructure funds. Other modes of financing such as debt are nevertheless possible alternative solutions, depending on the fund strategy and the infrastructure involved.

Direct investment in a project. Schematically: the investor finances an infrastructure project in direct collaboration with the public player and a consortium of public or private players (builder, operator, financier, and insurer). This can be done, in particular, in the form of a public-private partnership, such as a delegated public service, for example. The project generates financial revenues that remunerate the investor once the infrastructure is in operation. These revenues are generated from the fees paid by users or through subsidies from a public authority, depending on whether the infrastructure is economic or social. Figure 7 presents a simplified diagram of infrastructure project development. The advantage of financing a project through a public-private partnership is that, beyond recourse by a public player to private resources and expertise, the risks, notably climate risks – are shared according to each player's capabilities and know-how to manage them. This type of investment also makes it possible to insist on environmental criteria in selecting the infrastructure to be financed.

[14] Inderst, G. (2009).

Figure 7 – Simplified diagram of a project development process that integrates climate parameters

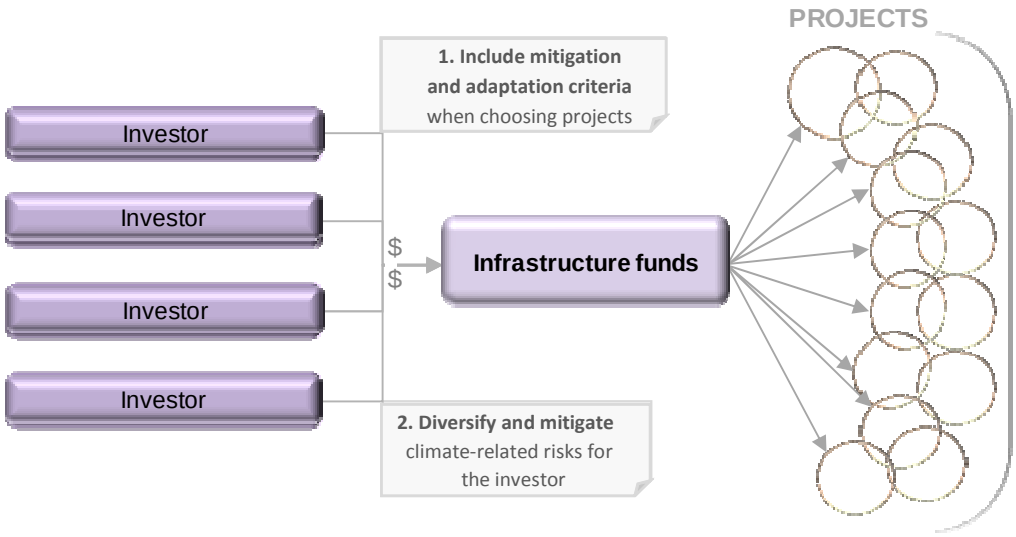


Investors choose the characteristics of the project they wish to finance. These selection criteria are reflected in project implementation through infrastructure construction and operation.

Source: CDC Climat Recherche.

Infrastructure funds are funds specialising in infrastructure investments; in many cases, their equity is financed by institutional funds such as pension funds. The economic and financial context of the last few years has given rise to numerous funds of this type, which view infrastructures as a financial opportunity. In 2006, the total amount of funds awaiting investment in infrastructure assets was between 100 and 150 billion dollars, according to the rating agency Standard & Poor's (S&P) – with the Australian group Macquarie alone managing 45 billion dollars of owner's equity. The rise of infrastructure funds can be explained by the advantages of investing in infrastructures (Part I) and of diversifying the risks, including climate risk. Indirect investment allows investors to diversify their risk within the same class of infrastructure assets. This mode of infrastructure financing also allows them to define the type of funds in which they wish to invest. Some funds orient their investment strategy towards financing clean energy or low greenhouse gas-emitting infrastructures. Similarly, they can integrate the requirement of adaptation to climate change into their choice of projects (Figure 8).

Figure 8 – Investing in infrastructure funds to diversify the risks



Source: CDC Climat Recherche.

A fund or an investor can therefore require compliance with certain environmental criteria for the infrastructures they finance. Instead of being subject to local, national or international regulations alone, they can choose to finance only infrastructures that meet a certain number of environmental criteria, including requirements regarding GHG emissions and adaptation to climate change. Communication about these actions can enhance the investor's image considerably, as the measures that are taken help protect the economy as a whole and therefore benefit everyone. However, this is not enough to justify the investments; in many cases, the financial justification for these actions entails environmental regulations favourable to this type of investment.

III. THE ROLE OF THE REGULATORY FRAMEWORK IN SUPPORTING INVESTMENT

A. Regulation as a guarantee and incentive to invest

As we saw earlier, mitigation and adaptation actions allow investors to reduce their climate risk, thereby ensuring more stable revenues over the long term. However, other gains and risks may result from these actions, which require public support.

Costs and risks of adaptation: the need for public guarantees

In addition to some potential benefits of enhanced image, adaptation to climate change can be advantageous for investors from the cost perspective. The cost analysis of adaptation actions can be compared to a study of opportunity costs. It is indeed interesting to compare the cost of climate-related impacts on an infrastructure to the cost of financing adaptation at the project scale. The results may or may not argue in favour of adaptation actions; the essential factor lies in developing the know-how, which consists in determining whether or not there will be further costs related to the adaptation of infrastructure projects.

The issue of cost comes in addition to supplementary risks linked to an adaptation action. There are three types of risk:

- *Technological risks.* One of the ways to make an infrastructure better adapted is by using technologies that are more flexible or more resilient to future climate change (see Part II). At the same time, as it all is the case for all new technologies, the use of new technologies that have yet to be tested or mastered may increase the technological risk.
- *Regulatory risks.* As the issues of adaptation to climate change are closely linked to land use, regulatory constraints may arise in the form of urban development rules. Thus, the investor will face permit and feasibility risks when building an adaptation infrastructure.
- *Information risks.* Lack of knowledge and information on actual climate trends could lead to maladaptation (See Part II). This risk may encourage investors to adopt no-regret strategies and support research carried out on the subject. At the same time, it is a reminder to public authorities of the need for public-private cooperation and support from public authorities at the international level.

Despite the advantages for investors of choosing adapted infrastructures to ensure the sustainability of their investments, the existence of these uncertainties acts as a new barrier to investment. This problem arises in addition to the urgent need for adaptation and reinforces the need for public authorities to develop guarantees and incentives for private adaptation financing.

A regulatory framework favourable to mitigation actions

The advantages for investors in terms of mitigation measures depend in large part on the type of action carried out: building insulation, transport, renewable energies, etc. Each activity can be analysed individually.

Financing renewable energy infrastructures is one of the most high-yield activities: intended to meet the growing energy challenges to come, renewable energies – particularly solar and wind energy – offer a genuine opportunity for investors today.

According to an RREEF study published in September 2009[15], investments in renewable energy production infrastructures are attractive for three main reasons. These three reasons are linked to the issue of costs and incentives to invest in low or carbon-free energies, namely:

- The cost structure of these investments, and more specifically the fuel supply cost and initial investment costs (Box 3).
- A conventional incentive in the form of subsidies and public aid for clean energy production. Sometimes, however, such subsidies may appear to be an institutional barrier to project implementation. In cases where public authorities subsidise clean energy through feed-in tariffs or other types of subsidies, they may restrict the number of authorisations to build this type of infrastructure to avoid seeing the amount of the subsidies exceed the estimated limit, as was the case recently in Spain. Thus, due to limited public funds, public authorities may refuse renewable energy projects that would result in an overall reduction of GHG emissions.
- An incentive linked to the cost of CO_2 emissions: if the cost is internalised through a system of carbon allowances – such as the European Emission Trading Scheme (EU-ETS) for example – or a carbon tax, CO_2 emissions sometimes increase in value. Numerous regulations based on the valuation of GHG emissions have been created in the last few years to give investors an incentive to enter this market. However, uncertainties about framework changes and constraints associated with GHG emissions could be dissuasive for investors. These uncertainties, which include risks such as the risk of legislative changes concerning carbon and clean technologies (e.g. feed-in tariffs, emission allowances, etc.), were at the heart of the latest climate change negotiations. The uncertainties about both the global system after 2012 and the associated financial mechanisms (Clean Development Mechanism and Joint Implementation, which allow investors to receive carbon credits convertible into cash in exchange for investing in a greenhouse gas reduction project) have been a disincentive to invest in projects until an international decision is made.

[15] Infrastructure Investments in Renewable Energy, RREEF Research Paper, September 2009, available at the following link: https://www.rreef.com/cps/rde/xbcr/ai_en/Infrastructure_Investments_Renewable9-09_LR.pdf.

Box 3 – An opportunity for sober investment in carbon:

The case of renewable energies

As is often the case for infrastructures, the initial cost of investing in renewable energy infrastructures is particularly high. Moreover, it sometimes carries a risk linked to the use of new technologies: the technologies have not always reached maturity, a problem that may result in increased risk of flaws in the technology used or a risk that the installed equipment does not perform as efficiently as expected.

However, the choice between a fossil-based energy production infrastructure and a renewable energy production infrastructure is often based on other factors. For most renewable energies, the massive long-term capital outlay (fixed costs) is offset by a far more attractive operating cost structure (variable costs) than for a fossil energy infrastructure. Unlike fossil-based energy production, which carries a cost for fossil fuel, renewable energy production from inexhaustible natural resources has no cost of this type. The variable costs of fossil-based energy production infrastructure, which include the cost of fossil fuels, increase with energy production. In contrast, the variable costs of most renewable energy production infrastructures (except for biomass energy production infrastructures) consist only of maintenance and operating costs, which are common to all infrastructures.

Putting aside the comparison of maintenance and operating costs, the initial investment cost, while particularly high, is equivalent to the cost of generating electricity throughout the life of the infrastructure.

Whereas the amount of the cost of capital invested might seem to be barrier to investment, this should not the case for institutional investors, which tend to prefer large-scale projects due to their higher returns. The cost structure is even optimal for long-term debt financing. Taking into account (1) the foreseeable increase in the price of fossil-based energy, (2) the constantly growing energy demand, (3) the increased number of regulatory and market incentives to invest in GHG emission reduction projects and (4) their advantages in the context of reducing climate risk, these investments therefore represent a genuine opportunity for long-term investors. Even better, the recent crisis has shown a relative de-correlation between these assets (excluding in the United States) and the traditional market: the value of financial transactions at the end of 2008 stood at 47.6 billion dollars, i.e. up by 41% compared with 2007. This rise in the sector continued in 2009 with a 15% increase in volume during the first quarter over the same period in 2008. In all, financial transactions in the sector rose by 238% between 2005 and 2008.

CDC Climat Recherche based on RREEF and Dealogic data.

Box 4 – The project for gas recovery from the Burwood landfill in the municipality of Christchurch, New Zealand

The value of emissions reductions can be enhanced within the scope of public policies to limit GHG emissions. For example, the project mechanisms of the Kyoto Protocol make it possible to obtain carbon credits that can be traded and valued on international carbon markets in exchange for a GHG emission reduction. The credits are delivered once the project is registered by the UNFCCC and the emission reductions have been observed by an accredited UNFCCC auditor. Investors who wish to finance this type of project are subject, along with the project sponsor, to specific criteria and conditions enabling the financial valuation of the emissions reductions. Chart 4 presents a sample project in which the emissions are currently being valued: a project for gas recovery from a landfill in Christchurch, New Zealand.

Chart 4 – Characteristics of the project for gas recovery from the Burwood landfill

Project	Landfill gas valuation in the municipality of Christchurch
Project description	Construction of a system allowing the use of methane produced by the municipal landfill to produce electricity and heat for the Christchurch municipal swimming pool
Motivations	* Take advantage of a greenhouse gas emission reduction action (landfill gas) * Engage in activities consistent with the local climate plan * Reduce community expenditures
Regulatory framework	National inventory of greenhouse gas emissions governed by the Kyoto Protocol, article 6
Financial characteristics	* Criterion of financial additionality: the project would not have been profitable without the valuation of GHG emissions * Initial cost of capital: USD 3 million (NZD 4.2 million)
Financial impact	* Reduction of community expenditures * Gains in terms of electricity and gas: USD 0.7 million per year (NZD 1 million) * Kyoto credits generated and sold: USD 2.1 million over 5 years (NZD 3 million)
Difficulties	* Audit of emission reductions * Coordination of the different actors involved * Coordination between the different levels (local and national)
	Project continued after the end of credit sales

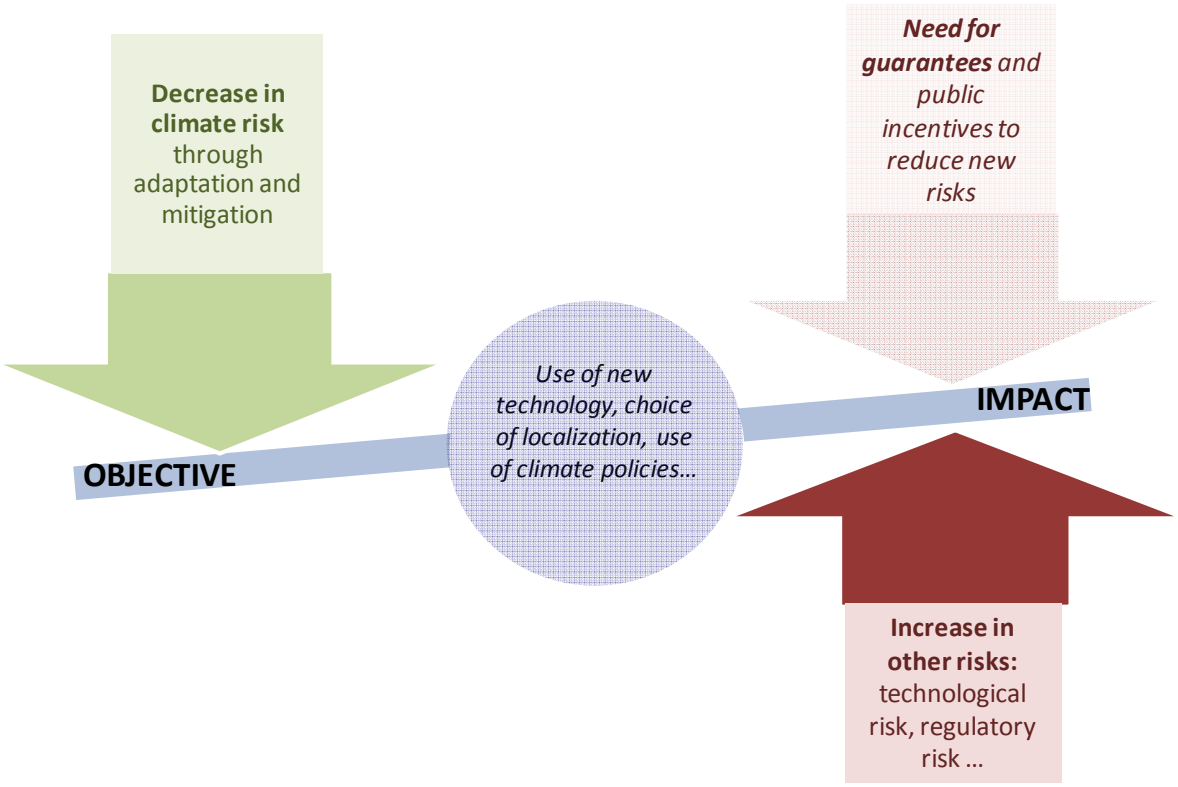
Source: CDC Climat Recherche based on Christchurch City Council.

Public guarantees dedicated to the climate

In both cases of mitigation and adaptation, new uncertainties and risks will appear that are difficult for private investors to assess. Due to a lack of information, expertise and experience, the private sector will be unable to manage these risks using traditional risk models. Figure 9 shows the process by which diminishing climate risks through adaptation and mitigation engender new risks. It shows why it is advantageous for public authorities to set up guarantee and incentive systems to help reverse the current trend towards higher non-climate related risks. Public guarantees for private infrastructures will usually be

decided on a case-by-case basis by analysing in each instance the ability of the private sector to assume certain risks and the advantage of having the public sector cover the others.

Figure 9 – Setting up guarantees and incentives to offset new constraints



Source: CDC Climat Recherche

Public sector incentives, such as guarantees and public funds, will be essential to make this type of project attractive for the investor.

An incomplete response in Copenhagen

One of the observations of the last Conference of the Parties in Copenhagen in December 2009 was that neither the public sector nor the private sector is capable of acting alone. On the one hand, the public sector lacks the funds to cope with climate challenges and on the other, private investors – especially long-term investors – require an international and national regulatory framework that provides greater visibility and security for their investments.

The Copenhagen Accord, the fruit of the Conference, thus ensures continuity in the steps towards cooperation between the public and private sectors, notably in the direction of developing countries. One of its conclusions is that a *transparent* and *reliable* environment should be created for mitigation and adaptation measures regarding both the source of the funding and the framework for their implementation. This conclusion applies in two ways:

- In terms of adaptation to climate change, the Accord emphasises that developed countries will have to provide resources – financial and other – that are *adequate*, *predictable and sustainable*.
- The mitigation actions taken by developing countries will be domestic *measurement, reporting and verification*. These countries will communicate the results of the implementation of their actions through national communications, with provisions for international consultations under clearly defined guidelines that will ensure that national sovereignty is respected.

These two recommendations testify to a general trend towards introducing a regulatory framework suited to private investment. However, it is not enough to observe the need for joint management of climate problems. Despite existing regulatory measures (e.g. carbon markets), the inadequacy of the regulatory changes provided by the latest negotiations has perplexed private investors. Indeed, they are faced with a demand that is both economic and climate-related and they need new guarantees and incentives to continue on this path.

B. The allocation of public funds: a lever for private investment

The public sector could attract private funds by providing guarantees and regulatory incentives to overcome the economic barriers that long-term investors face today. However, some recent proposals suggest strengthening public-private cooperation in the form of public levers for private investment.

The study published by the United Nations Environment Programme (UNEP) on public financing mechanisms[16] directly addresses the problems of creating a suitable public framework to attract private investors. According to this report, resorting to a public financing mechanism could leverage between 3 and 15 dollars of private investment for every dollar of public investment. The UNEP has therefore proposed to create public-private packages capable of mitigating the risks facing private investors in the case of low GHG-emitting infrastructures. These packages, which combine various approaches to facilitate and guarantee the financing of certain projects, will ensure some degree of revenue stability for investors. They will also act as a considerable lever to finance the fight against climate change, especially considering the limits of public finance.

Alongside the increased need for investments to combat climate disturbances and their consequences, governments across the world are increasingly acknowledging their inability to come up with the total amount of required financing. The World Economic Forum (WEF) estimates that public sector financial commitments on a global scale could reach at most 110 billion dollars per year for the fight against climate change if all the transfers of resources were operational, an amount that falls short of estimated needs by several hundred billion dollars. The inadequacy of public funding to finance directly all climate projects and policies reinforces the already obvious need to optimise the allocation of those resources. This optimisation will require in particular setting up mechanisms financed by public resources to leverage private funds, as explained above.

The main motivation for the public sector to introduce this type of mechanism is therefore to optimise the allocation of public resources in the face of considerable needs in order to preserve societies worldwide. This is especially the case in developing countries where ample investment opportunities exist but where these uncertainties and impediments to investment still discourage numerous investors.

IV. DEVELOPING COUNTRIES: A CROSSROAD BETWEEN NEEDS AND OPPORTUNITIES

A. Infrastructures in developing countries and the climate issue

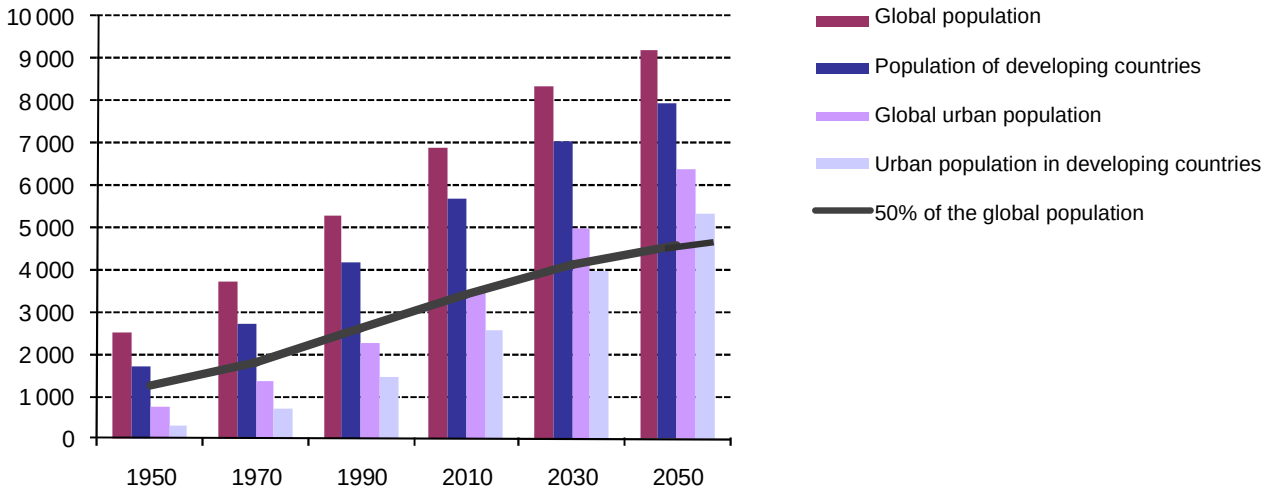
Increasing opportunities for investment in infrastructures

With rising population and significant urban expansion, developing countries are likely to experience the greatest demand for infrastructure in the coming years. According to United Nations forecasts, the world population is expected to reach 9 billion people by 2050. Of those 9 billion individuals, more than 5 billion will be living in the urban areas of developing countries (Figure 10). By 2025, for example, China is

[16] UNEP and Partners (2009a).

expected to have 220 cities of more than 1 million inhabitants, which, as gathering areas, will require a large number of infrastructures; in comparison, the European Union currently has 35 such cities.

Figure 10 – Evolution of global urban and total population of the world and in developing countries (in millions of inhabitants)



Source: CDC Climat Recherche based on a study by the Population Division of the Department of Economic and Social Affairs of the United Nations Secretariat, World Population Prospects: The 2006 Revision et World Urbanization Prospects: The 2007 Revision.

Building green infrastructures

Population growth will necessarily lead to an increased need for new infrastructure systems across the world, especially in certain emerging countries such as China and India. If the supply of low-carbon projects is inadequate, the rising demand for infrastructures will itself be synonymous with a considerable increase in energy consumption and consequently greenhouse gas emissions. Today, we have already observed that the energy consumption in developing countries rose by 176% between 1971 and 2005 compared with 46% for developed countries[17], an observation that reflects both the doubling of the population since 1970 and global economic development.

Investment in green infrastructures should make it possible to reduce the GHG emissions resulting from the growth of developing countries. Such investments will supplement current resources dedicated to developing countries. These public and private resources are often dedicated first and foremost to development and are generally insufficient to cover the additional costs arising from the use of low-carbon technologies. These investments also raise the issue of technology transfers between developed and developing countries.

Taking adaptation to climate change into account

The increasing number of extreme weather events is compounding the existing vulnerability of developing countries. Today, the vulnerability of these countries is tangible: according to insurance companies, 95% of the populations affected by extreme weather events are found in developing countries. The IPCC (2007) has declared that in all likelihood these countries will initially suffer the most from climate change. Indeed, they lack all types of resources – human, institutional, financial, technological as well as some infrastructures – to cope with climate catastrophes and therefore the climate change to come. Changes

[17] Source: International Energy Agency.

such as higher temperatures and water stress in Africa, the increased frequency of cyclones and heat waves in Asia and rising sea level for island states will result, for example, in reduced access to water and energy, flooding of infrastructures located in coastal areas and greater public health problems.

By including climate parameters in their infrastructure investments, long-term investors help to reduce the vulnerability of these countries while reducing the vulnerability of their own assets to climate change (adapted infrastructures). They also help resolve the problems of financing adaptation to climate change, a highly debated topic today.[18]

Infrastructures in developing countries – especially those in emerging countries – are a flourishing market for long-term investors. However, the infrastructure investments must include criteria for limiting GHG emissions and adaptation to climate change.

Development, mitigation, adaptation

Developing countries, particularly the least advanced, which cannot finance their actions to combat climate change by themselves, are at the heart of international discussions on climate issues. Unless they limit their GHG emissions, these countries will be responsible for major GHG emission growth resulting from the construction of new infrastructures. If limits are imposed, they may be subject to excessive constraints that will slow down their development. At the same time, in order for their development to be indisputable, it must take climate evolution into account and prepare for it – by adapting the regions.

Because they cannot finance these actions alone, the projects in these countries are calling for both public and private mobilisation at the international level, including long-term investors. One of the issues raised, to which the international community is attempting to respond, concerns the complementary nature of financing issues regarding development, mitigation and adaptation. No matter how they respond, resources are necessary, but securing supply to meet demand remains a difficult task today.

B. Current opportunities are ill suited to private investments

Despite the economic advantages mentioned earlier, in developing countries more than anywhere else, adapted and green infrastructure projects today are neither sufficiently large nor numerous enough for institutional funds to invest massively in them[19]. Indeed, the aim to maximize revenue orients investors towards large-scale projects with sizeable revenues, which are easier to monitor and manage, whereas many smaller-scale projects are required for regional development. At the same time, even if they showed an interest in a market of smaller projects, they would be faced with insufficient demand for financing[20] compared with the massive resources they are ready to invest.

Mechanisms offering incentives and guarantees for financing smaller projects, such as project aggregation mechanisms, can help change this situation. Financiers often try to group their funds and efforts to offer financing through equity, loans and subsidies, depending on the case. These funds can be managed by the private sector or by international institutions such as the World Bank.

The existence of a regulatory framework suited to these types of projects appears indispensable today. Risks and regulatory framework are both paramount factors in investment decision-making, particularly within the scope of international transfers in which the unstable context of certain developing countries increases the existing risks in infrastructure financing. In their efforts to attenuate these risks, investors are seeking a reliable, transparent regulatory and financial environment. Yet the risks we discussed earlier are intensified by the specificities of developing countries: exchange risks, country risks (geopolitical, etc.)

[18] For further information on this topic, see Research Note No.17 of Caisse des Dépôts Mission Climat on financing adaptation (A. Drouet, April 2009).
[19] UNEP and Partners (2009).
[20] UNEP and Partners (2009).

and credit risks (payment default), all of which are dominant characteristics of financial transactions between the developed and developing countries.

As we saw earlier at a global scale, here again public support is an element that could allow investors sufficient economies of scale to encourage them to invest in small-sized projects. This public support for international investments is possible in two forms[21]: subsidies on the one hand and credit guarantees and loans to reduce the cost of financing on the other. In particular, to attract long-term investors, public credit guarantees that attenuate certain risks (such as exchange risks, country risks or political risks) are one of the options recommended by several studies[22]. These recommendations do not exclude, however, other types of support to investment such as subsidies; they supplement regulatory measures and cooperative initiatives between the local and international levels. NAPAs are an example of such initiatives.

Facilitating North-South cooperation through a specific framework: the example of NAPAs

National Adaptation Programmes of Action or NAPAs are projects aiming at reducing vulnerability to climate change in Least Developed Countries (LDC). They identify the urgent needs of LDCs to adapt to climate threats, namely those projects for which a delay in implementation would result in higher costs and greater vulnerability. NAPA activities are financed in large part by public investors, notably the World Environment Fund's LDC Fund. Setting up these programmes creates a favourable environment for private investors by offering public guarantees for private players that wish to become involved in adaptation projects in the region of the NAPA.

At 3 December 2009, 43 countries had submitted NAPAs to the UNFCCC, the last ones being Togo and Afghanistan in September 2009[23]. The projects are of different types and do not necessarily correspond to the construction of infrastructures. A large percentage of NAPAs include risk prevention measures such as stronger building standards or risk prevention plans. The regulations are therefore conducive to building more resistant infrastructures, and thus to more stable revenues. Given the framework provided by the national entities involved, investors may nevertheless decide to invest in other types of intangible projects. The example of a NAPA project in Bangladesh (Chart 5) illustrates the type of measures included in NAPAs and shows why a NAPA might interest a long-term investor that wishes to become involved in a developing country.

[21] Hourcade et al. (2009).
[22] Hourcade et al. (2009), UNEP and Partners (2009A),
[23] http://unfccc.int/national_reports/napa/items/2719.php

Chart 5 – Example of a NAPA project in Bangladesh

Strengthening the ability of urban and industrial infrastructures to withstand climate change impacts including floods and cyclones

Project		Advantage for investors
Observation	The urban infrastructures of the country's main cities will be adversely affected by the impacts of climate change	*Mainly local benefit*
Objective	Improve resilience to climate change (floods and cyclones) in the urban and industrial sectors of the country's main cities	*Mainly local benefit*
Project	➲ Development of adapted construction standards ➲ Development of waste management systems for industries ➲ Development of systems to warn of flood and cyclone risks	*Mainly local benefit*
Potential effect	**Short term:** Better understanding of climate problems in the urban and industrial sectors **Long term:** Greater resilience of urban and industrial infrastructures to the impacts of climate change	**Framework for future projects**
Implementation	**Local agencies involved:** DOE (Department of the Environment of Bangladesh), Ministry of Industry of, DCCI (Dhaka Chamber of Commerce and Industry) **International agencies involved:** FBCCI (Franco-British Chamber of Commerce and Industry) **Evaluation:** Multi-sector Supervision Committee	**Guaranteed project monitoring**
	Risks and barriers: Poor knowledge and understanding of the problems within local entities	*Mainly local benefit*
Indicative cost	**Implementation:** 2 million dollars Design phase: 25,000 dollars	**Large financial transfer involved**

Source: http://unfccc.int/files/adaptation/application/pdf/napa_infrastruct.pdf

Most NAPAs are comparable to development projects in strategic sectors such as water and agriculture that will suffer as a result of climate change. Like development projects, many NAPAs never materialise due to institutional barriers, lack of suitability to the local context or lack of adequate human and financial resources or technical knowledge. In some cases as well the required investments exceed the resources available. Thus, to this day, of the 420 NAPA projects identified in mid-2009, only a few have been implemented.

CONCLUSION

The response of long-term institutional investors to the problem of infrastructures in the face of climate change will be vital for global economic viability. All economic activities, which depend on the proper functioning of the infrastructures that make them up, require that those infrastructures be adapted to the climate of the future. At the same time, infrastructures offer significant potential for emissions reductions – hence for mitigation of climate change – which must not be neglected in building new infrastructures and modernising old ones. This observation applies particularly to the large emerging countries, which, due to their growth and development, will be at the heart of tomorrow's climate issues.

The interests of long-term investors do not lie solely in concern for the general welfare; rather, they are primarily based on economic criteria of steady, sustainable revenues, criteria that are now threatened by climate change. Although there is considerable uncertainty about the coming climate change, they nevertheless represent a tangible risk for investors. As the traditional means of risk coverage have yet to fulfil their needs, investors can choose to attenuate these risks by reducing their emissions and adapting their assets to the future climate. Some impediments to investment still remain, which necessitate the introduction of a regulatory framework that will act as an incentive to attract investment in infrastructure projects.

To summarise, it appears to be in the interest of long-term investors today to incorporate the problem of climate change concretely and proactively into their calculation of the risk vs. profit potential of infrastructure investments. However, before they take the plunge on the scale required today, they will need the support of public policy incentives that provide a twofold benefit over the long term: an economic benefit – for the investor – and a social benefit – for the economy as a whole.

Some questions still remain unanswered. Which technologies are most effective for reducing GHG emissions with a minimum of risk? How can these emission reductions be measured and used advantageously? What is the best time to introduce a given adaptation action? Scientific research will no doubt answer some of these questions in the coming years, within a longer or shorter time frame depending on the case. We can also predict that long-term investors will find the means to answer certain questions in the course of implementing projects: they will learn by doing, since each project has its own characteristics. In all likelihood, the learning process will be long, complex and meticulous, like international climate issues themselves. It is nevertheless indispensable in view of the climate situation, and it promises to be highly instructive for all the public and private players involved.

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