*Chapter 3*

# Economic and Policy Instruments to Promote Adaptation

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*Adaptation to climate change will comprise of thousands of actions by households, firms, governments, and civil society. This chapter provides some pointers as to how smart policy can turn private initiative into a force for adaptation. It focuses on three instruments: insurance, environmental markets and public private partnerships. Insurance has a long track record as a way to share weather risks. However, as climate damages grow insurance will become riskier. Public policy measures will be needed to overcome this problem, for example through publicly funded adaptation measures that bring down risks or by sharing the most extreme layer of risks with commercial insurers. Public policy should not, however, subsidise the systemic risks, as this may sustain activities that become progressively less viable under the changing climate. Environmental markets and pricing have a key role to play in the preservation of natural systems, even without climate change. They incentivise owners to preserve natural assets and consumers to use them carefully. From an adaptation point of view, environmental markets and pricing serve two main purposes. First, they reduce baseline stress, making systems more resilient. Second, they can help to monetise the adaptation services provided by ecosystems. Public Private Partnerships (PPPs), meanwhile, can help to overcome operational constraints and accelerate investment in infrastructure, which will likely be the most expensive part of adaptation and, therefore, put considerable strain on the administrative and financial capacity of governments. PPPs may also play a role in research and development and the search for better adaptation technologies.*

## Introduction

Adaptation will comprise of thousands of actions by households, firms, governments, and civil society. Sustainable adaptation will require these actors to internalise current and anticipated climate risks in their various decisions, while being mindful of the associated uncertainties. Despite a long record of dealing with climate variability there is considerable evidence that many societies and sectors remain poorly adapted, even to current climate (IPCC, 2007, Chapter 17). Further, while there are now some examples of adaptation to long term climate change, progress in this direction has been more at the level of planning than actual implementation in both developing and developed countries.

There are clearly several bottlenecks here. A key issue is the cost of adaptation and access to adequate financial resources to meet this cost. Consequently, much of the policy debate has focused on the cost of adaptation, ways to raise public adaptation funding, and allocation of adaptation costs. What has received much less attention, however, are policy and institutional bottlenecks, in particular the role of market and regulatory mechanisms in facilitating adaptation. This is quite critical, given that a majority of actions are undertaken by private actors and also because the scope of the adaptation challenge will far exceed the public budgets available to address it.

While some adaptations will provide public benefits, such as protection of coastal areas from sea level rise, many others will offer private benefits that accrue to individuals or firms, or to a consortium of such actors (Lecocq and Shalizi, 2007). Self-interest should be a sufficient incentive for such individuals or groups to undertake adaptive measures that reduce their vulnerability. Like the activities of markets, these actions do not have to be directed centrally by a public authority. In fact, this would be counter-productive and probably impossible. However, as in the case of markets, governments are called upon to provide an enabling environment that allows private agents to make timely, well-informed and efficient adaptation decisions. Where private actions fail because of external effects or other failures, governments may also have to provide adaptation as a public good. Conversely, the scale and/or efficiency of many adaptations typically undertaken by governments could be enhanced through engagement with the private sector. Again, mechanisms might need to be in place to catalyse such engagement and to ensure that it leads to the desired outcomes.

The purpose of this chapter is to move the discussion beyond cost estimation to policy instruments for promoting adaptation. The term "policy instrument" is used broadly to include mechanisms used to achieve a desired effect through economic or legal means. Like other areas of environmental policy, these policy instruments can be directed at using markets, creating markets, regulation and legal arrangements, and engaging the public. The only qualification is that in the context of adaptation the desired effect is the reduction of adverse impacts (or enhancement of beneficial effects) due to climate change.

The rest of this chapter is organised as follows. The next section establishes the framework for examining the role of policy instruments within the context of adaptation. The nature of adaptation activities is discussed, followed by an analysis of typical climate change impacts and adaptation strategies in key climate sensitive sectors. This helps in the identification of key policy instruments which could be used to facilitate adaptation. Next, three instruments are identified that could play a key role in adaptation: insurance, price signals and environmental markets, and Public Private Partnerships (PPPs). Insurance is a recurring instrument within the context of adaptive responses in a number of sectors, particularly agriculture. Price signals and environmental markets, meanwhile, might be critical to adaptation in many climate sensitive natural resources including water and ecosystems. PPPs could potentially play a very critical role in financing and enhancing the climate resilience of infrastructure, where the costs of adaptation are disproportionately high, but also in the research and development (R&D) of new adaptation technologies. These three instruments are discussed sequentially in the following three sections. Each of these sections examines the nature and current use of the instruments, their strengths and limitations, and relevance for adaptation. The final section offers some concluding remarks.

## Scope of adaptation policy instruments

The process of adapting to climate and climate change is complex and multifaceted. It covers all aspects of society and consists of a multitude of behavioural, structural and technological adjustments. As such it is difficult to do adaptation analytical justice, and a number of typologies have consequently been developed to classify adaptation activities. For example, adaptation measures have been classified according to: timing (anticipatory *vs*. reactive); scope (short-term *vs*. long-term, localised *vs*. regional); purposefulness (spontaneous *vs*. planned, passive *vs*. active adaptation); and adapting agent (private *vs*. public adaptation, societies *vs*. natural systems).

For the purpose of examining policy instruments, it is suitable to employ the following classification of generic adaptation options introduced in the IPCC Third Assessment Report (IPCC, 2001, Chapter 18, after Burton, 1996):

- **Bear losses.** Bearing loss occurs when those affected have no capacity to respond in any other ways (for example, in extremely poor communities) or where the costs of adaptation measures are considered to be high in relation to the risk or the expected damages.

- **Share losses**. This involves spreading the losses among a wider community. Such actions take place both in traditional and modern societies. In traditional societies, losses are typically shared among extended families and village-level or similar communities. Complex modern societies share losses through insurance, public relief, rehabilitation, and reconstruction paid for from public funds.

- **Modify the threat**. For some risks, it is possible to exercise a degree of control over the environmental threat itself, for example via flood control.

- **Prevent effects.** A frequently used set of adaptation measures involves steps to prevent the effects of climate change. These measures can in turn be grouped into: *(i)* structural/technological measures; *(ii)* legislative/regulatory instruments; *(iii)* institutional / administrative measures; *(iv)* market-based instruments; and *(v)* on-site operations.

- **Change use**. Where the threat of climate change makes the continuation of an economic activity impossible or extremely risky, consideration can be given to changing the use. For example, farm land may be converted back into wetlands to protect coastal zones.

- **Change location.** Another response is to change the location of economic activities. There is considerable speculation, for example, about relocating major crops and farming regions away from areas of increased aridity and heat to areas that are currently cooler and which may become more attractive for some crops in the future.

- **Research.** The process of adaptation can be advanced by research into new technologies and new methods of adaptation, for example in agriculture (new cultivars) and health (new treatments for climate change-related diseases).

- **Encourage behavioural change through education, information and regulation**. Another type of adaptation is the dissemination of knowledge through education and public information campaigns, leading to behavioural change.

Identifying specific policy instruments that facilitate these generic adaptation strategies requires additional detail on the specifics of the impacts faced by particular sectors as well as the potential adaptation strategies. Starting with the main impacts of climate change across key sectors, Table 3.1 lists some of the main adaptation measures that fall under the above-mentioned generic categories. The last column of this table then identifies specific policy instruments that can be used to facilitate these adaptations.

Table 3.1 shows that in principle there might be a range of policy instruments that can facilitate adaptation in the various sectors. The table of course is intended to be illustrative and not comprehensive. Nevertheless, it does have a number of recurrent policy instruments that are relevant to adaptation in many sectors, including:

- **insurance schemes** (majority of sectors),
- **price signals/markets** (*e.g.* water and ecosystems),
- **PPPs** (*e.g.* flood defence, coastal protection and water),
- **microfinance schemes** (*e.g.* agriculture, weather extremes),
- **regulatory incentives** (*e.g.* building standards and zone planning),
- **R&D incentives** (*e.g.* agriculture and health).

The following sections examine the first three of these instruments, *i.e.* insurance schemes, price signals and environmental markets, and PPPs in further detail. Specifically, the focus is on the description and current application of each of these instruments, their strengths and limitations, and whether and how they can be applied to address the specific challenges posed by climate change.

## Risk sharing and insurance

Insurance – risk sharing – has been used to deal with climate variability and weather risks for centuries. Risk sharing owes its popularity to notions of economic efficiency, risk aversion, and a sense of solidarity at times of hardship. It is also good business. The insurance sector is a vital part of modern financial markets. It is also a sector that has already been forced to evolve in order to cope with new varieties of environmental risk. As climate changes and historical weather records become less useful, the insurance sector will have to develop new ways of spreading risk away from those affected, while encouraging those at risk to adapt to the new environment.

Table 3.1. **Climate impacts, adaptation options and policy instruments**

| Sector | Main impacts | Adaptation options | Potential policy instruments |
|---|---|---|---|
| Agriculture | Reduction in global yields of crops like rice, wheat, maize and soybean, with particularly high losses in tropical areas close to temperature thresholds and arid, semi-arid areas. Direct and indirect (through quality and quantity of food, water) impact on farm animals (health, growth, milk and wool production, fertility). Increased prevalence of pests, weeds and disease. There are also positive impacts, including increased productivity in some crops due to $CO_2$ fertilisation; longer growing seasons in high latitudes. | • Share the loss: crop insurance<br>• Prevent the loss (structural, technological): investment in new capital<br>• Prevent the loss (market-based): removal of market distortions (*e.g.* water pricing)<br>• Prevent the loss (market-based): liberalisation of agricultural trade to buffer regionalised losses<br>• Change use: change of crops, planting dates, farming practices<br>• Research: development of heat and drought resistant crops | • Price signals/markets<br>• Insurance instruments<br>• Microfinance (*e.g.* to finance capital investment)<br>• R&D incentives |
| Coastal zones | Inundation, flood and storm damage through sea surges and backwater effects; wetland loss; erosion; saltwater intrusion in surface and ground waters; rising water tables and impeded drainage. | • Prevent the loss (structural, technological): coastal defences/sea walls; surge barriers; upgrade of drainage systems, saltwater intrusion barriers<br>• Prevent the loss (on-site operations): sediment management; beach nourishment; habitat protection (*e.g.* wetlands, mangroves)<br>• Prevent the loss (institutional, administrative): land use planning<br>• Change location: relocation; set back areas | • Regulatory incentives (zone planning)<br>• Price signals/markets (*e.g.* differentiated insurance premiums; valuation of ecosystems)<br>• Financing schemes (PPPs or private finance for coastal defence schemes) |

Table 3.1. **Climate impacts, adaptation options and policy instruments (cont.)**

| Sector | Main impacts | Adaptation options | Potential policy instruments |
|---|---|---|---|
| Health | Higher incidence of heat stress and heat-related mortality; particularly in cities and during heat waves; fewer winter deaths; change in the prevalence of vector borne diseases, such as malaria and dengue fever. There will also be health effects from extreme weather events (see below). | • Prevent the loss (structural, technological): air conditioning, building standards<br>• Prevent the loss (institutional, administrative): improvements in public health; vector control programmes; disease eradication programmes<br>• Research: R&D on vector control, vaccines, disease eradication<br>• Education/behavioural: behavioural change (work breaks, maintain hydration) | • R&D incentives<br>• Regulatory incentives (*e.g.* building codes)<br>• Insurance |
| Water resources | Change in the volume, timing and quality of water flows; increased rainfall variability; change in peak streamflow from spring to winter; more frequent and severe water shortages; flooding after severe water discharges; decrease in water quality through salination, higher temperature, lower flow in some areas (higher flows in others). | • Prevent the loss (structural, technological): loss reduction (leakage control; conservation plumbing); capacity increase (new reservoirs, desalination facilities)<br>• Prevent the loss (institutional/administrative): water allocation (*e.g.* municipal *vs.* agricultural use); risk management to deal with rainfall variability<br>• Prevent the loss (market-based): water permits, water pricing<br>• Education/behavioural: rational water use, rainwater collection | • Price signals/markets (water pricing, trade in water permits)<br>• Regulatory incentives (hosepipe bans, etc.)<br>• Financing schemes (adjustments to terms of water PPPs) |

Table 3.1. **Climate impacts, adaptation options and policy instruments (cont.)**

| Sector | Main impacts | Adaptation options | Potential policy instruments |
|---|---|---|---|
| Ecosystems | Change in the extent, distribution and health of species; migration (*e.g.* fish stock, birds); change in behaviour (*e.g.* earlier nesting); loss of species unable to move or too slow to adapt. | • Bear the loss: increase ecosystem resilience (*e.g.* reduce baseline stress)<br>• Prevent the loss (legislative, regulatory): habitat protection (*i.e.* reduce baseline stress)<br>• Prevent the loss (institutional, administrative): change in natural resource management (*e.g.* sustainable fishery, forestry); environmental policy<br>• Prevent the loss (market-based): eco-tourism, market for ecological services<br>• Change location: facilitate species migration (*e.g.* migration corridors)<br>• Research: breeding and genetic modification for managed systems | • Price signals/markets (*e.g.* ecosystem markets)<br>• Regulatory incentives (*e.g.* zone planning; environmental standards)<br>• Microfinance schemes (*e.g.* ecotourism)<br>• R&D incentives |
| Settlements and economic activity | Malfunctioning infrastructure; redirection of tourist flows (summer heat, lack of snow, sea level rise); migration/change in population dynamics; increase in energy demand from space cooling, but reduction in winter heating demand. | • Share the loss: insurance, weather derivatives<br>• Prevent the loss (structural, technological): climate-proofing of housing stock and infrastructure<br>• Change location: zone planning, location decisions | • Regulatory incentives (building standards)<br>• Price signals/markets (*e.g.* adaptation-dependent insurance premiums)<br>• Insurance schemes<br>• Financing schemes (adjustments to infrastructure PPPs) |

Table 3.1. **Climate impacts, adaptation options and policy instruments (cont.)**

| Sector | Main impacts | Adaptation options | Potential policy instruments |
|---|---|---|---|
| Extreme weather events | Higher frequency and severity of extreme weather events, such as hurricanes, floods and storms. Damage to infrastructure, housing stock; interruption of economic activity; direct health effects through death and injuries, indirect health effects from water contamination and bad sanitary conditions. | • Share the loss: insurance; spreading of risks beyond the insurance industry (*e.g.* through cat bonds)<br>• Prevent the loss (structural, technological): flood barriers; storm/flood-proof infrastructure, housing stock<br>• Prevent the loss (institutional, administrative): early warning systems; enhanced disaster management<br>• Change location: zone planning, location decisions | • Insurance schemes<br>• Price signals/markets (*e.g.* adaptation-dependent insurance premiums)<br>• Regulatory incentives (building codes, zone planning)<br>• Financing schemes (private finance or PPPs for defence structures) |

From a public policy point of view, the question will be whether these adjustments result in a sufficient level of insurance cover and a fair allocation of risk. This section reviews the adaptation challenges in the insurance sector.

### *Scope of current products*

**Traditional indemnity-based insurance** covers the policy holder against the loss of an asset (such as a crop or a home) and has long been used to also address weather related risks. A core weakness of these products is the moral hazard created by the indemnity based products. Although this method should result in the payout being close to the actual loss incurred, there is a perverse incentive for the insured party not to undertake risk reduction if they know that the damage will be covered by a claim based policy. In such cases insurance may actually impede adaptation or even promote maladaptation. Furthermore, traditional insurance involves asymmetric information. This occurs when one party has more or better information than the other creating an imbalance in power in transactions, which can lead to an under- or over-estimation of risk. Finally, the settling of claims is time consuming and costly.

A potential solution to some of these problems has been the creation of different trigger options that may be more suitable for dealing with climate change related risk. In particular, as a large number of weather conditions can be quantified, for example rainfall, temperature and wind speed, insurance products can be triggered by a predetermined quantified weather scenario. Beyond these "parametric" triggers, index-linked options have also been developed that calculate the payout according to "industry loss" and "modelled loss" triggers.

**Index-based insurance** reduces moral hazard since payment and actual damage are not directly linked. As the insured party receives a payout irrespective of the losses experienced, the incentive to prevent and mitigate risk is preserved. There is no need for an assessment or verification of actual damage so the transaction costs are lowered and the speed of payout is improved. These benefits are particularly relevant when designing schemes to insure parties in developing countries who are at risk from catastrophic weather conditions.

In addition, index-based insurance can facilitate the transfer of risk to capital markets by standardising contracts. By basing contracts on publicly available information, the asymmetries associated with traditional insurance are reduced, encouraging greater participation. Finally, index insurance will incentivise greater measurement of weather patterns and the development of more sophisticated models. Table 3.2 summarises close to 30 index insurance schemes that have been put in place in developing countries in recent years.

Table 3.2. **Summary of index-based risk transfer products in lower income countries**

| Country | Risk event | Contract structure | Index measure | Target user | Status | Source |
|---|---|---|---|---|---|---|
| Bangladesh | Drought | Index insurance linked to lending | Rainfall | Smallholder rice farmers | In development. Pilot launch planned for 2008. | Barnett and Mahul, 2007 |
| Caribbean Catastrophe Risk Insurance Facility | Hurricanes and earthquakes | Index insurance contracts with risk pooling | Indexed data from NOAA and USGS | Caribbean country governments | Implemented in 2007 | Barnett and Mahul, 2007; Isom, 2007 |
| China | Low, intermittent rainfall | Index insurance | Rainfall and storm day count | Smallholder watermelon farmers | Implemented in Shanghai only in June 2007. Includes a 40% premium subsidy. | Barnett and Mahul, 2007 |
| Ethiopia | Drought | Index insurance | Rainfall | WFP operations in Ethiopia | USD 7 million insured for 2006. Policy not renewed for 2007 due to lack of donor support. | Skees *et al.*, 2006; Syroka and Wilcox, 2006 |
| | Drought | Index Insurance | Rainfall | Smallholder farmers | 2006 pilot, currently closed due to limited sales. | Barnett, Barret and Skees, 2008 |
| | Drought | Weather derivative | Satellite and weather data | NGO | Implemented 2007 | Swiss Re, 2007 |
| Honduras | Drought | | Rainfall | | In development | Syroka, 2007 |
| India | Drought and flood | Index insurance linked to lending and offered directly to farmers | Rainfall | Smallholder farmers | Began with pilot in 2003. Now index insurance products are being offered by the private sector and the government. | Manuamorn, 2007; Ibarra and Syroka, 2006 |
| Kazakhstan | Drought | Index insurance linked to MPCI programme | Rainfall | Medium and large farms | In development | Barnett and Mahul, 2007 |
| Kenya | Drought | Weather derivative | Satellite and weather data | NGO | Implemented 2007 | O'Hearne, 2007 |
| Mali | Drought | Weather derivative | Satellite and weather data | NGO | Implemented 2007 | Swiss Re, 2007 |

Table 3.2. **Summary of index-based risk transfer products in lower income countries (cont.)**

| Country | Risk event | Contract structure | Index measure | Target user | Status | Source |
|---|---|---|---|---|---|---|
| Malawi | Drought | Index insurance linked to lending | Rainfall | Groundnut farmers who are members of NASFAM | Pilot began in 2005. 2 500 policies sold in 2006 pilot season. USD 7 000 in premium volume. | Alderman and Haque, 2007; Leftley and Mapfumo, 2006 |
| Mexico | Natural disasters impacting smallholder farmers, primarily drought | Index insurance | Rainfall, wind speed and temperature | State governments for disaster relief. Supports the FONDEN programme. | Pilot began in 2002. Available in 26 of 32 states. Currently 28% (2.3 million ha) of dry land cropland is covered. | Agroasemex, 2006a; Skees *et al.*, 2006 |
| | Major earthquakes | Index-linked CAT bond and index insurance contracts | Richter scale readings | Mexican government to support FONDEN | Introduced in 2006. CAT bond provides up to USD 160 million. Index insurance coverage up to USD 290 million. | Wenner, 2007; Cardenas, 2006 |
| | Drought affecting livestock | Index Insurance | Normalised difference vegetation index | Livestock breeders | Launched in 2007. Sum insured USD 22.5 million across 7 states. Insured 913 000 cattle. | Agroasemex, 2006b |
| | Insufficient irrigation supply | Index insurance | Reservoir levels | Water users groups in the Rio Mayo area | Proposed | Skees and Leiva, 2005 |
| Mongolia | Large livestock losses due to severe weather | Index insurance with direct sales to herders | Area livestock mortality rate | Nomadic herders | Second pilot sales season of pilot completed in 2007; 14% participation. | Mahul and Skees, 2005; Skees and Enkh-Amgalan, 2002 |
| Morocco | Drought | Index insurance | Rainfall | Smallholder farmers | No interest from market due to declining trend in rainfall | Barnett and Mahul, 2007; Skees *et al.*, 2001; Stoppa and Hess, 2003 |

Table 3.2. **Summary of index-based risk transfer products in lower income countries (cont.)**

| Country | Risk event | Contract structure | Index measure | Target user | Status | Source |
|---|---|---|---|---|---|---|
| Nicaragua | Drought and excess rain during | Index insurance | Rainfall | Groundnut farmers | Launched in 2006 | Barnett and Mahul, 2007; Syroka, 2007 |
| Peru | Flooding, torrential rainfall from El Niño | Index insurance | ENSO anomalies in Pacific Ocean | Rural financial institutions | Proposed | USAID, 2006; Skees, Hartell and Murphy, 2007 |
| | Drought | Index insurance linked to lending | Area-yield production index | Cotton farmers | Proposed | Carter, Boucher and Trivelli, 2007 |
| Senegal | Drought | Index insurance linked to area-yield insurance | Rainfall and crop yield | Smallholder farmers | Proposed | Barnett and Mahul, 2007; Swiss Re, 2007 |
| Tanzania | Drought | Index insurance linked to lending | Rainfall | Smallholder maize farmers | Pilot implementation in 2007 | Barnett and Mahul, 2007; Swiss Re, 2007 |
| Thailand | Drought | Index insurance linked to lending | Rainfall | Smallholder farmers | Pilot implementation in 2007 | Barnett and Mahul, 2007; Manuamorn, 2006 |
| Ukraine | Drought | Index Insurance | Rainfall | Smallholders | Implemented in 2005, currently closed due to limited sales. | Barnett and Mahul, 2007; Skees, Hess and Ibarra, 2002 |
| Vietnam | Flooding during rice harvest | Index insurance linked to lending | River level | The state agricultural bank and, ultimately, smallholder rice farmers | In development, a draft business interruption insurance contract is being considered by the state agricultural bank. | Skees, Hartell and Murphy, 2007 |

The inherent disadvantage of index insurance is the lack of relation between the predetermined payout and actual damage. This “basis risk” results in a potential lack of correlation between premium and payout that is difficult to correct due to the increasing unpredictability of the climate. Also, “parametric” index-based triggers only cover one potential cause of damages, for example low rainfall leading to drought, leaving the sponsor unprotected against other causes of failure, for example, poor seed. So while the market for index insurance is still immature, further developments are required in order to encourage more extensive participation from the private sector. One such advancement is the creation of hybrid triggers that use more than one trigger type in a single transaction or tranche. These can be used on multi-peril transactions using a different kind of index trigger for each. Alternatively, hybrid triggers can involve the application of different trigger types in a sequential fashion in order to determine the loss from a covered event.

**Weather derivatives** are financial instruments that can be used as part of a risk management strategy to reduce the risk associated with adverse or unexpected weather conditions. This market instrument covers low cost, high probability events and the most common contracts are based on temperature indexes. It also covers contracts on rainfall, snowfall and storm risks. These instruments were the first form of index insurance, where payouts are linked to the occurrence of a certain weather event. In 2002, it was estimated that USD 1 trillion of the US economy was weather-sensitive, implying an enormous potential market for these new hedging instruments.

Weather derivatives are now entering their second decade of existence. Despite a decline in contracts between 2006-07, the trading volumes and values are still above pre-2006 levels and with climate change awareness growing, financial markets are likely to continue to base products on the increasingly variable weather patterns. In particular, energy utilities use these derivatives to hedge against the consequences of temperatures deviating from the seasonal average. Weather derivatives also have potential for other sectors whose profits are affected by the weather, including agriculture, retail sales, the leisure sector and the construction industry. In order to present marketable products to these new customers, the market has diverged from temperature-indexed contracts to derivatives of precipitation, both rain and snow and wind. One likely development given the general market conditions is a move towards more cross-market trading and correlation strategies with other markets. In particular, there is great potential demand from companies seeking to hedge their greenhouse gas emissions risks. The strong link between weather, levels of energy generation and therefore emissions will encourage power generators to structure trades that combine carbon and weather derivatives.

**Catastrophe bonds**. As the relationship between payouts and premiums has become increasingly distorted, insurers have come to realise that they lack the resources to deal with large-scale losses on their own. In order to enable them to continue offering protection against extreme events, one option has been to attract extra funding from the capital markets by securitising some of the risk in bonds, which could be sold to high-yield investors. Catastrophe (cat) bonds are such securities that transfer risk from sponsors to investors. The coupons are normally a reference rate plus an appropriate risk premium. However, if the bond is triggered (through a pre-defined loss or index-based level), the investor will forfeit a preset amount of the capital invested and the insured party receives a payout relevant to the degree of loss or scale of index. Although the "cat" bonds have primarily been used in developed countries, their viability is currently being examined by the World Bank for developing country contexts.

**Other instruments**. Two instruments that are currently being explored to address climate-related risks are Pooling Cash Reserves and Debt Indemnification. **Pooling Cash Reserves** are being tested as a form of collective self-insurance by the Eastern Caribbean Central Bank which is accumulating mandatory contributions from member governments. These reserves could be used to draw loans in case of natural disasters. **Debt Indemnification** is being used under the Commonwealth and Smaller States Disaster Management scheme. It provides insurance to risk-prone governments so that they can continue to service their debt following natural disasters based on a flat rate premium of 1% of the value insured (Burton *et al.*, 2006).

## *Implications for adaptation*

The immediate effect of climate change will be to raise the demand for insurance products. Increased weather variability will make risk reduction a more attractive proposition. However, climate change will also increase the cost of insurance and this may curb some or all of the extra demand. Higher weather variability and more extreme events will mean higher expected losses and higher payouts. Insurance companies will pass on that extra cost to clients wherever possible. Moreover, uncertainty about climate change will make insurance more risky, at least in the short term, as historic statistics and loss probabilities can no longer be relied upon. Insurance providers will want to be compensated for that extra risk.

The challenge for the insurance industry, as it seeks to reduce climate change risks and turn climate change into a business opportunity, will be two-fold. First, there will be a need for extra capital and ways to spread risks beyond the relatively small insurance sector. This is necessary to absorb higher average payouts and to deal with more frequent and higher spikes in payouts following an extreme event. Catastrophe bonds have, in the past, been used to spread insurance risk in the financial sector more broadly. In fact they have been specifically designed for that purpose, and as such they may gain more prominence as the climate changes. Other companies may choose mergers or "rights issues"[1] to increase their financial depth.

The second challenge for the insurance sector is to improve the accuracy and resolution of hazard data and the likely impacts of climate change. Although insurance companies are beginning to use simulation models to estimate likely loss profiles, the pricing of premiums is still based on historical records, which are no longer a reliable guide for future weather-related losses. However, developing an analytical understanding of future climate change risks is extremely difficult. An accurate risk assessment requires detailed knowledge not only of the physical impacts of climate change at the regional level (precipitation, temperature, wind speeds, frequency and severity of extreme events) but also of socio-economic developments and adaptation measures that affect insurance density and future vulnerability. Insurance companies will look to public bodies – universities, meteorological offices and research laboratories – for relevant climate information and vulnerability data. Some of the necessary research may be sponsored by the insurance companies or carried out jointly with their in-house research teams. For example, in the European Alps where climate change has implications for a number of natural hazards, insurance companies are beginning to examine these implications on their pricing and, in one case, are also funding the development of climate change scenarios (Jetté-Nantel and Agrawala, 2007). However, despite any improvements in climate forecasting capabilities, a fundamental challenge in anticipating future climate risks is that many of the climatic changes are not monotonic, which makes identification of trends very difficult. The challenge this poses for pricing insurance schemes is illustrated through the case of rainfall in the Sahel in Box 3.1.

1. Means of raising equity whereby a company offers its current shareholders the right to purchase a specified number of additional shares at a specified (attractive) price within a specified time.

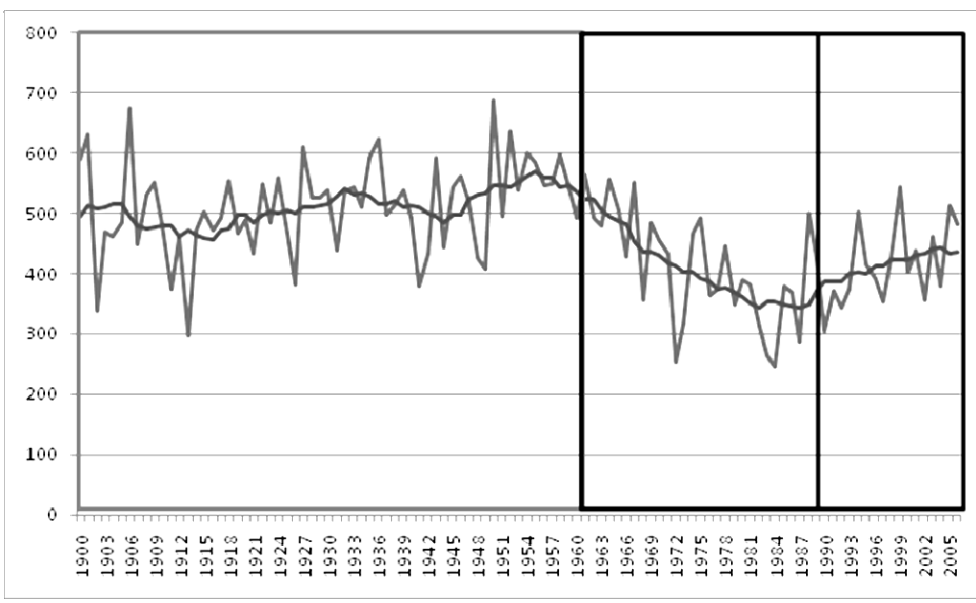
## Box 3.1. **Rainfall variability and the challenge of pricing insurance**

As index insurance is being increasingly pursued as a tool to address the risks of climate change in developing countries, caution is needed to understand whether or not it might, in fact, be an appropriate strategy. In theory, the process of pricing weather index insurance provides an indication of risk exposure: the higher the exposure, the higher the insurance premium. Relaying this information to the potential insured gives clear signals regarding the costs of the risks and, may provide the necessary incentives for the required adaptations.

Pricing weather risk in the future, however, is extremely difficult. Consequently, premiums are often set based on historical data of the index (such as rainfall). The problem, however, is that past trends might not accurately reflect future outcomes. This is further complicated if the historical record shows different trends over different periods of time, which is not entirely uncommon for rainfall. In this case, depending on the time reference used, the insurance premiums could be very different and may send very different signals in terms of adaptive responses.

This is illustrated by using the example of rainfall in the Sahel, where rainfall was centred around an average of 500 mm between 1900 and the early 1960s, followed by a steady decline until the mid-1980s, and an upswing since then (see figure below).

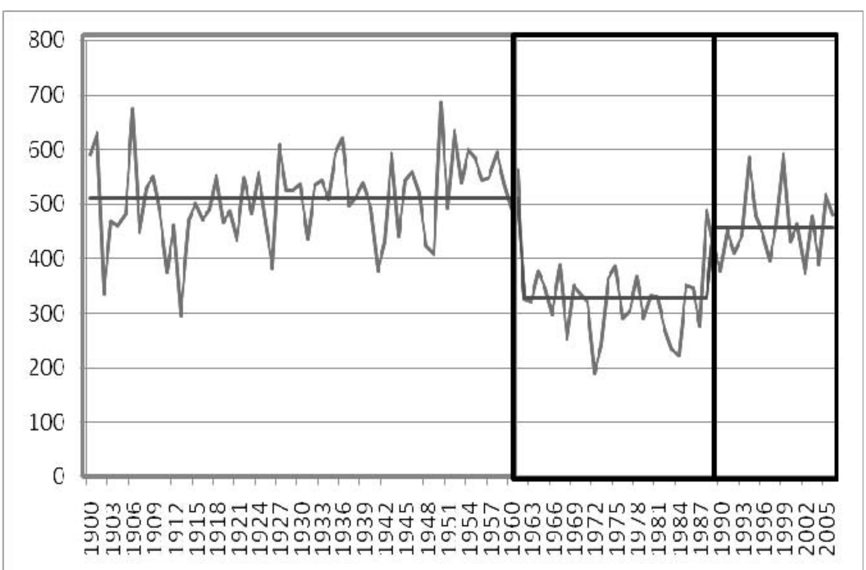
**Sahelian rainfall from 1900 to 2006**



Imagine the hypothetical case of providing insurance for the dominant crop in the region which requires 400 mm annual rainfall to sustain. If a farmer needs a contract that pays when rainfall is less than 400 mm, one can consider how an insurance provider might begin pricing such a contract with the vantage point of having data from different periods in time (1900-61, 1962-89, and 1990-2006), as shown in the figure above. For 1962, the historical record (1900-61) would reflect a slight upswing, centred around 500 mm of rainfall. For 1990, meanwhile, having only data from 1962 to 1989 would result in a very different conclusion about the future average rainfall as the forecast from this series of data is around 310 mm. While for 2007, the recent historical record (1990-2006) would reflect a slight upward trend again.

An insurer having the vantage point of using only data represented in each of the panels in the figure above, would adjust the data by accounting for the trend. The second figure, below, illustrates the type of adjustments that would be done to "remove the trend" and re-centre the variance in the data around the forecasted trend data at the end of each of the three time periods. Writing a rainfall insurance for rainfall below 400 mm would be feasible at the end of the data in the first time period, and likely at the end of the data in the last time period. It would clearly not be feasible at the end of the data that appear in the middle time period. In this case, the forecast of the central tendency for 1990 is 310 mm. Based on the information from the middle time period, a policy that pays for rainfall below 400 mm would be expected to pay in every year, which is clearly not viable.

**Weather data adjusted for trends given the vantage point of 1962, 1990 and 2007**



**Important lessons**

The Sahel case, while somewhat unique, has two important pointers for pricing insurance under climate change. First, it highlights the limitations of using retrospective information as a guide to pricing premiums when the parameter that is being indexed is exhibiting considerable variability. Second, the experience from the middle period that is examined (1962-89) shows that insurance may not be a viable option if there is a monotonic trend in the central tendency. In this case insurance was clearly not suitable for the point of reference for 1990. During the 1970s and 1980s, the region was experiencing a strong desiccation trend, which would have led to very high insurance premiums. In this situation, subsidising insurance premiums to improve household access to insurance is more likely to hinder needed household adaptations to the new climatic conditions, increasing household risk in the long term. Thus, if there are distinct trends in weather data that change the central tendency, insurance is less likely to be a viable solution. Attempting to subsidise the cost of insurance when the central tendency is changing will be more costly and more clearly recognised as a subsidy by farmers, and consequently, more likely to delay adaptation.

*Note:* Figures created by GlobalAgRisk, Inc. (2008) from data provided by International Research Institute for Climate and Society, Columbia University.

From a public policy point of view, the main issue is whether the adaptation action taken by the insurance industry results in the "right outcome" in terms of the availability and level of cover and the distribution of risks. In an ideal scenario, competitively priced insurance products would send an accurate signal to the market about the economic cost of climate risks. Firms and households would respond to the price signal by climate-proofing their businesses and homes (to reduce premiums) or, if the premium is considered too high, by relocating to a less risky area. The result would be an efficient level of insurance cover and residual adaptation.

In reality this is unlikely to be the case. Several factors drive a wedge between the theoretical and actual outcome. First, as long as climate impacts are uncertain, insurance companies, which are risk-averse themselves, will overcharge for climate risk or refuse coverage of risks that might otherwise be insurable. Second, budget constraints, inertia and cultural factors will prevent people from adapting fully in the short term, especially if the optimal response is relocation. Third, insurance cover is by no means universal. Among poor households and in poor countries in particular it can be patchy.

Public policy measures may be needed to overcome these market imperfections. For example, they may take the form of publicly funded adaptation measures to bring risks (and hence premiums) down to an acceptable (and hence insurable) level. Public policy can also facilitate the sharing of climate risks between the insurance sector and the state. Risk sharing would probably take place under a structure where regular risks are underwritten by the private sector, but exceptional damages, or damages above a certain level could be assumed by the state. Such a risk layering approach could be viable if climate change results in increased variability but without any significant changes in the central tendency (Skees *et al.*, 2008; Mahul and Skees, 2007). In this case the government could subsidise the most extreme layer of risk without creating perverse incentives and impeding adaptation decisions that might be needed to respond to more systemic climate risks. Broader use of premium subsidies, however, may reduce incentives to move away from activities that become progressively less viable under the changing climate.

## Price signals and environmental markets

Natural resources, such as water, forests and ecosystems are already under considerable pressure from human activity. Climate change will add to that pressure, and it is the combined effect of global warming and these "baseline" stress factors that matters when considering the impact of climate change on natural systems.

Baseline stress from pollution, overexploitation and mismanagement has many causes, but at the root of it, from an economic point of view, is the fact that property rights over natural resources are ill defined and their services are not valued properly in the market. Water resources are overused because water is too cheap and fish stocks are overexploited because they are a common property. Economic theory has a ready-made solution to overcome these market failures. The external benefits of natural resources have to be given a market value, either by factoring them into the price (say, through environmental charges) or by creating environmental markets.

Internalising the external benefits of natural resources in this way contributes to sound adaptation for two main reasons. First, it reduces the baseline stress on ecosystems. This is a measure that makes sense even without climate change. It is also good adaptation because it makes ecosystems more resilient to cope with climate change. Second, environmental markets and pricing will facilitate adaptation by providing stronger signals about the increased scarcity of some resources (such as water) and the higher economic benefits of others. For instance, the adaptation benefits of forests (in terms of soil quality and watershed protection) and wetlands (in terms of coastal protection) are not yet reflected in the market value of these resources.

There is vigorous discussion about the extent to which economic mechanisms are actually effective in practice. There are questions about the social outcomes of trading schemes. In the case of water, one key concern would be the need to ensure that everybody has affordable access to a minimum amount of water for personal use. In some cases there are practical issues about the equity of access to markets and the potential market dominance of important players.

However, these issues can be addressed and there are many cases where natural resources can be treated as a commodity in economic terms. This section draws on such cases to illustrate the opportunities and risks of using pricing and environmental markets to encourage and promote adaptation behaviour. The focus is on water pricing, water markets and payment for ecosystem or environmental services (PES).

### *Water pricing*

Water supply is usually addressed as three (interrelated) sub-sectors of use: domestic/municipal; industrial; and agricultural/irrigation. In many countries, even developed ones, irrigation is the biggest user in absolute terms. Whatever the use, water is very often under-valued and under-priced, especially in developing countries. This is a regulatory and policy issue. Since water supply is a natural monopoly (due to network externalities) prices are generally established by regulatory process rather than by pure supply and demand forces. The water policies of most development institutions stress the importance of efficient pricing mechanisms to promote optimal water use and encourage conservation (see for instance ADB, 2001). However, pricing reform is often difficult institutionally, politically and socially, even before climate change increases water scarcity and the competition for water resources.

In the agricultural sector, the price of water tends to be furthest away from long-run marginal costs. Moreover, water allocation is often tilted in favour of agricultural use, even though municipal use is generally of much higher value (see Briscoe, 1996). Irrigation water pricing is slowly moving towards more realistic levels, but there remains wide variation, particularly in developing countries. The pricing of irrigation water and the best way to achieve pricing efficiency remains a highly complex issue.

In the urban sector, water pricing is typically more advanced. Nevertheless, there remain difficulties and challenges. In particular there is a need to identify tariff structures that address the trade-offs between financial sustainability, efficiency of allocation, and social impacts, which include affordability (see Fankhauser and Tepic, 2007).

In the industrial sector, prices are typically closest to real cost levels (since it is politically easier to increase industrial charges than domestic ones). As might be expected, industry does respond to water prices, although in many cases the changes take time, if capital investment is required to achieve improved water efficiency.

A significant issue in responses to increased prices in all sectors is that users respond (in an economically rational way) by switching to groundwater, which is often outside the control of the local water agencies. Because groundwater is very often an under-priced or effectively free resource, users will switch once water supply costs rise above the costs of groundwater abstraction (which are generally low). This effect has been seen in urban areas with major industrial users and in rural areas with large scale irrigation users. It is a consequence of lack of control over access to a common resource, with predictable consequences of overuse, wastage and serious resource depletion. Establishing control over groundwater resources is therefore one of the major institutional challenges for water resource managers in countries across the world. It is a particular concern in the context of increasing water scarcity and variability since groundwater normally responds slowly to changes in surface water conditions and so has traditionally been a "backup" in many areas.

### *Water markets*

There are some good examples of water markets, particularly – but not exclusively – in OECD member countries. As part of the effort to support adaptation to climate change, the challenge for policy makers is to understand the conditions in which some markets flourish and are effective and to promote the institutional changes that will encourage further open markets.

Water markets are not new: farmers and other users have always traded at the margin but structured formal markets are of more recent origin. The basic requirements for formal trading are clearly defined, exclusive and transferable rights to a defined quantum of water. This can introduce issues related to measurement of water (in time and in location) but markets generally require less information than systems that use allocation to try to achieve efficiency.

In most countries where water is scarce, systems of rights to water have emerged either informally through customs or conventions or formally through laws and regulations. Formalisation of these rights is the critical step to encouraging expanded markets. For a number of reasons, not least a culture of free market approaches, formal water markets have emerged in three main areas: the western United States; Chile; and Australia. The country which has addressed water scarcity and the use of markets most directly and in the most integrated fashion is Australia, where adaptation to climate change is critical to the country's economic future (see Box 3.2).

In developing countries, formalisation of large scale water markets has not yet occurred, although there are many small scale activities. In India, where there are a great number of irrigation systems, there have been various examples of informal markets (see Box 3.3).

Price mechanisms to encourage efficiency and cost recovery are also used in the Mediterranean Basin, although true water trading is not yet established. Most climate models predict reduced precipitation levels for this region, adding to an already considerable baseline stress. In Tunisia, water management responsibilities and costs have shifted to Water User Associations (WUAs). A special feature of the Tunisian approach is the creation of associations of underground-water users that will improve management of the water requirements of all irrigators using a shallow aquifer. Experience will show whether such WUAs can manage aquifers in a sustainable manner. The outputs of this measure have been water savings of 25% and an increase of 33% in water-use efficiency (IPTRID, 2001). In Egypt and Turkey, WUAs have also been key to increased efficiency, while in Jordan and Morocco the public sector had a greater role in promoting water efficiency (Vidal *et al.*, 2001).

### *Payments for ecosystem services*

In the past decade, there has been increasing development of the use of payments for environmental or ecosystem services (PES) as a mechanism to take account and recognise the value of environmental services to society. In this arrangement some of the beneficiaries of ecosystems pay the provider for services received, and by doing so ensure the conservation of that particular ecosystem source. PES also improves rural livelihoods and thus contributes to sustainable development. Although still in its infancy, PES has been recognised as a promising new environmental policy, and developing these markets has been a central part of recent conservation efforts.

PES has been described as a method for internalising the positive externalities associated with a particular ecosystem. The success of PES schemes depends on a well-understood market for services, with a well-defined service (or specific land use which supports the service), and clear providers and buyers of the service who are both willing to enter into a voluntary transaction on transparent payment conditions, usually upon delivery of the service (Pagiola *et al.*, 2004; Wunder, 2005). In reality very few schemes fulfil these conditions.

## Box 3.2. **Australian water markets**

Water trading in Australia was legislated in the 1980s as a demand side management approach to alleviate emerging water scarcity. The purpose of establishing regulated markets was to encourage a more efficient use of an increasingly scarce resource, by allowing water to move from low productive uses to high productive uses.

The Murray Darling Basin (MDB), which is the catchment for the Murray and Darling Rivers accounts for the majority of water trade in Australia. The MDB is home to 2 million people and extends across four states. The majority of trade is conducted within states although a pilot interstate water trading project was introduced in 1998. Water trade is conducted between irrigators once the government has announced its annual allocations depending on the availability of water supply. The system prevents over consumption and regulates the amount of water diverted from the basin in accordance with seasonal flows. In drought years the allocations are much lower to reflect the shortage in water supply. Concerns about the environmental sustainability of the basin and the unpredictability of seasonal flow patterns have led to a capping system on the volume of water diverted from the basin.

Due to the variability of seasonal allocations, entitlements can be traded on a temporary or permanent basis. A temporary transfer of entitlements allows the buyer access to the seller's water allocation for a particular season. This enables farmers to adjust to changes in supply between seasons and manage risk during times of drought. Farmers have the option to sell entitlements when prices are high or buy entitlements when prices are low. Permanent transfers allow the buyer access to the seller's water entitlement for the current season as well as all future entitlements. The majority of trade that occurs in the MDB is on a temporary basis. This is largely due to the fact that permanent entitlements are more expensive and also the uncertainty that surrounds future government allocation announcements.

Over the last year the Murray Darling Basin has been affected by the most severe drought on record. Thus farmers have become more dependent on the market to either increase their allocations to sustain agricultural output, or as a source of financial compensation. There have been several economic gains from water trading in Australia, as the transfer of water entitlements has moved from low value uses to high value uses. Large irrigators are confident that in times of water shortages, water can be obtained from the market albeit at a high price. Smaller farmers can use the market as a form of financial insurance against low productivity. Market prices have increased over the last year to reflect shortages in water supply caused by drought. In the Murray irrigation region, prices rose from a high of AUD 140 per mega litre in the 2005/06 season to a high of AUD 800 per mega litre in the 2006/07 season. The total value of water traded in this region rose from AUD 4.2 million to AUD 12.3 million.

There are some concerns about the capacity of water markets to cope with the threat of increasing water shortages and greater climate variability as a result of climate change. However, water markets in Australia are proving to be an efficient way of managing the pressures of water shortages and an effective adaptation strategy to cope with the effects of climate change. The success of the markets can be attributed to the legislative and institutional framework established by the Australian government through which trade is conducted. This ensures that water entitlements are clear, well-defined, tradable rights. Furthermore the separation of water entitlements from land ownership means the rights to water can easily be transferred, this has also allowed for a more equitable distribution of water supply. The regulatory role of the government has also ensured that over consumption of water resources does not occur at the expense of environmental degradation of the basin.

*Source*: Murray Darling Basin Commission (www.mdbc.gov.au); Bentley (2007).

### Box 3.3. **Informal water markets in India**

Informal water markets have developed in irrigation communities across India as a response to both actual and perceived shortages in water supply. Informal water markets are characterised by the absence of any legislative or institutional framework through which trade is conducted. The emergence of water markets is a response by communities to problems of water scarcity at a non state, localised level.

While informal water markets exist in many regions of India, they are most developed in water scarce, irrigation communities of Gujarat, Tamil Nadu and Andhra Pradesh. Water trade in these regions is mainly conducted between large landowner farmers with access to groundwater systems (sellers) and poor farmers with very little or no access to irrigation water supplies (buyers). This exchange is reinforced by riparian rights that exist in India, which tie water rights to land ownership, as well as by the high costs of developing infrastructure to extract groundwater. Poor farmers thus rely on groundwater markets for irrigation purposes.

Groundwater is extracted via tube wells using either electric or diesel pumps. Farmers extract water in excess of what is required for their own irrigation purposes and sell the surplus locally to neighbouring farmers. Payment is made either through cash, labour or sharecropping where water is paid for by a proportion of the buyer's output.

The establishment of informal markets in India has alleviated the stress of water shortages for many irrigation farmers and led to a more efficient allocation of water resources. Water trading has led to significant gains particularly for smaller irrigation farmers, who without informal water markets would be denied access to water resources.

However, water markets in India have been developed without any legal and institutional framework and are thus characterised by high monopolistic prices, unreliable source of supply and overexploitation of groundwater resources. Access to groundwater is limited to a few large landowners who are often able to charge prices above the market rate. This has priced some farmers out of agriculture, although a more equitable allocation of water exists in the case of sharecropping. The absence of a legislative or regulatory framework has also led to the overexploitation of groundwater resources, as farmers are not limited by a capping system. Groundwater extraction by pumping has also been indirectly encouraged through subsidies for fuel and electricity.

For water markets to work effectively, clear and well defined entitlement rights to water need to be institutionalised. With the growing threat of climate change and the associated problems of water scarcity India will have to find a way to adapt to problems of drought and variability of climate. Formal markets with a legislative and regulatory framework can offer a way of allocating scarce resources efficiently whilst reducing problems of monopoly power and overconsumption.

*Source*: Mohanty and Gupta (2002).

The services that ecosystems provide are varied and extensive but in practice, PES schemes have mainly concentrated in four areas:

**Watershed protection**. Payment for watershed protection schemes are primarily undertaken at a local level and concerned with ensuring water quality and flow, sediment retention and flood reduction. Transactions between buyers and sellers are localised and usually occur at the watershed level between upstream and downstream water users. An example of watershed protection is that of hydroelectric companies who pay land users to adopt practices that will not compromise the quality of water they need to operate. UNECE (2006) has developed guidance for using PES in the context of integrated water resources management, under the Convention on Transboundary Watercourses. However, the guidelines are based more on conceptual understanding than specific experience, with only a handful of examples quoted.

**Carbon sequestration**. Carbon sequestration involves both the active absorption of carbon through afforestation and reforestation and the avoidance of emissions through forest conservation. Carbon sequestration plays a prominent role in the international climate debate. As such it is expected to be one of the main drivers for PES schemes, creating a link between adaptation and mitigation. Afforestation and reforestation projects are already eligible under the Clean Development Mechanism (CDM) of the Kyoto Protocol, although few projects have been developed so far. It is likely that the scope will in due course be broadened to include emission reductions from avoided deforestation and forest degradation.

**Biodiversity protection**. Biodiversity payments are primarily made on an international level. Payments are made to protect ecosystems that hold endangered species or genetic biodiversity. Key potential payers for these services include international pharmaceutical companies and scientific research agencies that wish to take advantage of genetic biodiversity in these ecosystems. Conservationists are also key buyers of biodiversity services in order to ensure environmental conservation and sustainability (UNEP, 2006).

**Landscape and cultural preservation**. Landscape and scenic beauty services are associated with upholding the cultural and aesthetic value of specific ecosystem sites. Businesses involved with ecotourism, non-governmental organisations (NGOs) and conservation groups are the main potential buyers of this service.

Most efforts to use economic approaches to promote conservation concern the forestry sector. Wunder (2005) identified 287 "PES-like initiatives" in the forestry sector but noted that very few, if any, would meet the basic criteria of a PES scheme listed above. For example, the money often comes from donors rather than commercial user/buyers and the services purchased are frequently vague at best.

There are, however, a number of more commercially structured PES schemes. Most projects are in Latin America, with a growing number also in Africa, mainly related to wildlife conservation and parks. With support from donors, many environmental groups have been active in PES schemes for conservation purposes. An inventory developed by the Organisation of American States lists 83 examples of PES in the Americas.[2] Many of these are for carbon sequestration (either CDM or voluntary) or fall under formal schemes in Costa Rica and in Mexico, which concentrate, heavily on watersheds. Payments for watershed protection are also known in Colombia (see Box 3.4). An example of a private PES scheme in an OECD country is the Vittel scheme in north-eastern France (see Box 3.5).

There are also some examples of bundled services being marketed for instance in Latin America, where The Nature Conservancy purchased large areas of land, in effect, for the wide range of services that they provide. This approach can be simpler in concept but may be more costly and more complex to manage.

### Box 3.4. **Community-based watershed protection: the case of Columbia**

In the Valle de Cauca region of Columbia a community based initiative to protect watershed services has been established by local farmers and sugar cane producers as a response to the growing levels of water scarcity in the region. The Guabas River Water User Association (Asogaubas) was set up by the community to protect upstream watershed areas. Payments for watershed protection are collected by the association from users with charges reflecting water consumption levels. The Association regulates upstream land use by either purchasing land vulnerable to soil erosion or by issuing land management contracts to upstream landowners who prevent over grazing in vulnerable areas to ensure soil stabilisation. The association acts as an intermediary between downstream users and upstream land owners, collecting fees, maintaining watershed protection and providing financial compensation for some upstream farmers.

The Asogaubas has been a success in maintaining water quality and flow and the concept has spread across Columbia. In the Rio Cauca region alone, 11 additional water-user associations have been set up to regulate water flow and quality covering 1 million hectares and including 97 000 families. Columbia now hosts several water user associations across many of its river catchments areas.

The demand for water user associations by local communities reflects the need for watershed protection in the face of growing water scarcity. With the added stress of climate change on water resources, payment for watershed protection either through the establishment of markets or water user associations will be needed to regulate and maintain water supply.

*Source*: Landell-Mills and Porras (2002).

2. http://ranpa.net/PES/tProjectPES/ShowTProjectPESTablePage.aspx

Box 3.5. **The Vittel PES scheme**

Vittel (Nestle Waters), a leading brand in the mineral water industry, has developed a PES arrangement with local farmers in north-eastern France in order to maintain the quality of its water source.

Sold as a "natural mineral water" Vittel must, in keeping with French legislation, not contain any pesticides, nitrite and no more than 4.5 mg of nitrate per litre. In comparison, the maximum level of nitrate in French tap water is 50 mg, demonstrating the necessity for Vittel to protect the mineral composition of its water source. French legislation also states that mineral water cannot be treated to change mineral composition.

During the 1980s the quality of the Vittel water source had been compromised by local farming activities. Agricultural intensification in the aquifer and excessive leaching of farm land upstream had led to increasing levels of nitrate contamination downstream. In order to address this issue and conserve the quality of the water source, Vittel encouraged local farmers to change their farming practices by offering financial incentives to do so. Incentives also included technical assistance and training programmes for adapting to new farming methods. Farmers' income levels were to be maintained at all times. By 2004 Vittel had successfully negotiated the changes and developed a mutually beneficial arrangement with farmers and an appropriate incentive structure to preserve the quality of its water source.

The Vittel PES scheme took several years to implement. Part of the complex process was the creation of an independent institution to safeguard the interests of farmers and many of the incentives provided were not purely financial. However the Vittel case study demonstrates how a privately driven initiative can help to maintain an existing ecosystem.

*Source*: Perrot Maître (2006).

### *Relevance of environmental markets and pricing for adaptation*

Environmental markets and pricing – for water, forests or other ecosystem services – help to use these resources more efficiently. Prices send a signal about the scarcity of resources that incentivises owners to preserve their value and consumers to use them carefully. Markets ensure allocative efficiency. That is, they make sure resources are used for the purpose that creates the highest social welfare – whether this purpose is commercial (for example, timber logging), environmental (the preservation of species) or a combination of both (eco-tourism).

From an adaptation point of view environmental markets and pricing serve two main purposes. First, they reduce baseline stress on ecosystems, making them more resilient to cope with the added pressure of climate change. Second, environmental markets can be used to internalise, or monetise, the adaptation benefits of ecosystems.

For the first purpose it is not necessary to adjust market mechanisms specifically for adaptation. However, adaptation will be one more reason to increase the scale and scope for markets in water, forestry and other ecosystem services. Most of these schemes are still in their infancy and often still at an exploratory stage. Many more environmental markets and PES schemes are required simply for the protection of the natural environment. In this situation, the prospect of climate change may in fact strengthen the case for and urgency of schemes that would otherwise be rejected or delayed. As Easter and Zekri (2003) observed, in sectors, such as water, change usually only comes about when there is a "powerfully articulated need for reform." The additional pressures posed by climate change only reinforce the need for finding pricing mechanisms that simultaneously address efficient allocation of water resources across sectors as well as efficient use of water within each sector.

In the case of forestry, there are additional synergies with climate change mitigation. It is likely that the development of environmental markets in the forestry area over the coming decades will primarily be driven by the desire to reduce greenhouse gas emissions from deforestation and open the forestry sector to the carbon market. Carbon sequestration benefits are a key factor that can tip the balance in favour of sustainable forestry solutions that would also help the adaptation of forest ecosystems to climate change.

While "more of the same" may be the primary adaptation response if the objective is to reduce baseline stress and signal scarcity, adjustments in the design of environmental markets may be needed if the objective is to monetise the adaptation benefits of ecosystems (that is, to achieve the second purpose mentioned above).

One of the most relevant examples in this respect is the establishment of markets for watershed services. Watershed protection services provided by forests play a vital role in maintaining both the quality of water supply and regulating water flow. Forests around key water resources provide protection against flooding as well as maintaining dry season flows. They provide protection against soil erosion, and regulate the water table, maintaining adequate levels of nutrients in water supply. These services will become more valuable as rainfall becomes more erratic and water resources more scarce. Watershed protection thus plays an important role as an adaptation strategy protecting water resources from the effects of climate change.

The protection of watershed services has traditionally been overseen by governments. However, with growing scarcity of water supply, markets are being established by the private sector to ensure water quality and reliable supply. In most payment for watershed protection transactions, downstream beneficiaries pay upstream providers to maintain the quality of water supply/flow by avoiding changes in land use and behaviour, such as forest conversion, overgrazing and pesticide use which will compromise the quality of water for downstream users (see Box 3.4 above). Payments for watershed services thus essentially allow the redistribution of water resources by financially compensating upstream users. It is a market based mechanism that attempts to reconcile disputes over scarce water resources. As such it may be an effective adaptation mechanism against the threat that climate change poses on water resources.

Another good example of the adaptation value of ecosystems is mangrove forests. There are many examples of mangrove protection and restoration efforts and there is wide recognition of the value of mangroves (and other coastal systems) for protection against storm surges, waves and so on – a value that will increase with climate change. As a consequence of Hurricane Katrina, there has been considerable discussion of the value of the coastal systems of Louisiana in protecting New Orleans (or failing to) and efforts have been made to incorporate these values into cost-benefit analyses of options for the future of the city.

Elsewhere, natural habitats may serve as migration corridors, allowing species to move in response to a changing climate. More speculatively, the genetic diversity contained in natural systems may help in the R&D of heat and drought-resistant crops.

Despite this evident potential, there is little, if any, attention given to adaptation in the discussion of PES schemes so far. There are no examples in the readily accessible literature of PES related to these functions. Many practical problems remain, for example in terms of linking adaptation and traditional ecosystem benefits. Some coastal systems that are targeted for their biodiversity value can bring an adaptation function as an additional benefit. However, the adaptation value may not be the objective of the conservation effort and may, therefore, be neglected. Alternatively, there are areas which could have significant value in terms of adaptation but which are not biodiversity "hot spots" and so may not attract support from the conservation community.

The most important difficulty of these schemes, however, may be to find someone willing to pay for the protection provided, especially when these services are difficult to quantify and have traditionally been free. The need exists for "creative thinking" to help the ecological values to be realised in contexts where the general population is frequently very poor and where coastal management is often virtually non-existent.

## Public private partnerships

The estimates of global costs of adaptation reviewed in Chapter 2 suggest that adaptation will cost several billion dollars annually in developing countries alone. The bulk of the funds – up to 60–75% according to one estimate – is earmarked for infrastructure investments. This includes both the construction and operation of dedicated defence structures, such as flood barriers, and the climate-proofing of existing infrastructure, such as roads, bridges, water systems and electric power networks. These estimates are imperfect and inaccurate, but they show just how expensive adaptation might be.

In most countries the majority of infrastructure expenditures are met from the public purse, either at the national, state or municipal level. The same is true for climate protection measures, both in terms of physical structures (sea walls, flood defences) and institutional arrangements (emergency services, disaster relief). Adaptation will thus put a considerable strain on government resources, both financial and administrative.

Faced with either operational or financial constraints (or both), governments often look to the private sector to enhance their ability to provide public services. Private sector participation or PPPs (the terms are used interchangeably here) are no panacea, but there are many cases where carefully structured private solutions have helped to overcome operational constraints, enhance performance and accelerate investment. Adaptation solutions based on PPPs would be able to draw on a considerable body of experience on how to structure private participation in infrastructure – and increasingly in other sectors such as R&D, health and education (see for instance EBRD, 2004, 2007). This section reviews the experience and draws lessons for the adaptation debate.

### *Forms of PPPs*

Private sector participation can take many forms (see Table 3.3). Under full divestiture, the private sector takes ownership over all assets (for example, an electricity distribution network) and has control over all investment, maintenance and operations decisions (subject to regulatory oversight). Outright asset sales were the preferred form of private sector involvement in the early days, especially in developed countries. In developing countries, the private sector was usually invited to provide new installations needed to meet a growing demand. New (so-called greenfield) investment, rather than privatisation (the sale of existing assets), has been the dominant form of private sector participation in the developing world.

Greenfield investment and divestiture are particularly prevalent in energy and telecoms, where they account for more than 60% of private projects.

Table 3.3. **Types of private sector participation**[1]

| Type of contract | Subtype | Number of projects |
|---|---|---|
| Divestiture | Full | 167 |
| | Partial | 596 |
| | **Total divestiture** | **763** |
| Greenfield project | Build, lease and own | 14 |
| | Build, own and operate | 617 |
| | Build, own and transfer | 766 |
| | Merchant | 548 |
| | Rental | 18 |
| | **Total greenfield** | **1 963** |
| Concession | Build, rehabilitate, operate and transfer | 381 |
| | Rehabilitate, lease or rent and transfer | 58 |
| | Rehabilitate, operate and transfer | 414 |
| | **Total concession** | **853** |
| Management and lease contract | Lease contract | 102 |
| | Management contract | 112 |
| | **Total management and lease contract** | **214** |
| All types | **Total** | **3 793** |

1. The table does not include schemes in developed countries such as the UK PFI.

*Source:* World Bank Private Participation in Infrastructure Database (ppi.worldbank.org).

In transport and water, where competition in the market is more difficult to introduce, the most popular form of private sector participation is concessions. Concessions are long-term contracts, often of several decades, under which the private sector assumes full responsibility for the operation and management of an infrastructure asset, including investment and rehabilitation. However, ownership remains with the state. The long contract duration makes it possible for the private partner to recoup the often sizeable investment costs. The private partner gets remunerated primarily from project revenues (for example tariff collections), although in recent schemes commercial risk has been shared more evenly between public and private partners.

The Private Finance Initiative (PFI), pioneered in the United Kingdom but now also adopted in other parts of the OECD, is an example of concessions that include both infrastructure and non-infrastructure projects. In the United Kingdom, PFI schemes have been used to build GBP 56 billion (USD 111 billion) worth of schools, hospitals, police stations, government buildings and various types of infrastructure, according to UK Treasury statistics.[3] Unlike in classic concession arrangements, the private partner does not participate in commercial success. Given their public sector nature, PFI projects rarely have a commercial revenue stream. Instead, the private operator gets paid based on performance targets.

The final form of private sector participation in infrastructure is management and lease (or affermage) contracts. These contracts are shorter in duration – typically around five to seven years – and less risk and responsibility is transferred to the private sector. The private operator typically assumes responsibility for management and operations and is remunerated according to pre-agreed performance targets. Investment remains the responsibility of the public party. Management and lease contracts have increased in popularity, particularly in weak institutional environments, where private investors have scaled down their risk appetite. Their share in private infrastructure projects has gone up from 4% in the 1990s to 10% during 2001-05 (Kerf and Izaguirre, 2007).

PPPs are also used outside infrastructure. A particularly relevant example for adaptation is public-private joint ventures on R&D, which may help to accelerate the development and deployment of adaptation technologies. Under these partnerships, government agencies team with NGOs and private companies, with each party contributing "human, physical, and financial resources to foster the generation and diffusion of innovations, new forms of technologies, and knowledge" (Hartwich *et al.*, 2007), and implicitly, with each party bearing some of the associated risks. Box 3.6 describes two examples from health and agricultural research.

3. www.hm-treasury.gov.uk/documents/public_private_partnerships/ppp_pfi_stats.cfm.

### Box 3.6. **PPPs for R&D**

Technological innovation is crucial for reducing the costs of adapting to climate change, especially in industrial sectors and geographic areas where climate change will force drastic changes. Basic economic theory, however, shows that the private sector will under provide R&D because technological innovation has elements of a public good, as knowledge spillovers and other externalities prevent private innovators from capturing the full return on their investment. Thus, there is reason for the public sector to actively promote innovation investments. Public private partnerships, fiscal incentives, and intellectual property protection are the main methods through which governments promote R&D.

Public private partnerships are already being used in climate change adaptation. For example, in the agricultural sector developing heat and drought-resistant varieties of staple crops could make the difference between continued agricultural growth and mass food shortages. The International Maize and Wheat Improvement Centre (CIMMYT), which forms part of the Consultative Group on International Agricultural Research (CGIAR), has initiated the Drought Tolerant Maize For Africa (DTMA) Project in an effort to develop more drought-resistant varieties of maize. The project combines scientists from the CIMMYT with over 50 partners including national agricultural research institutes in Sub-Saharan African countries, advanced research institutions, NGOs and private sector seed companies. Donor organisations provide funding to research institutes that have developed 50 different varieties of drought resistant maize. The researchers then use private seed companies and community-based seed organisations to distribute the seeds to farmers in Sub-Saharan Africa, where to date over 1 million hectares of these seed varieties have been planted.

In addition to its direct effects on economic output, climate change may also significantly accelerate the spread of tropical disease. Therefore, medical research aimed at finding more effective cures and treatments could greatly improve health adaptation to climate change. However, the private sector under provides R&D for many neglected diseases, such as malaria, cholera, and tuberculosis, because the potential cures are less profitable than cures for other diseases. Public private partnerships can be effectively used to realign these research incentives. For example, the Medicines for Malaria Venture is a non-profit organisation dedicated to developing new anti-malarial drugs explicitly through public private partnerships. Launched in 1999, this venture combines the expertise of the pharmaceutical industry in drug discovery and development; knowledge of public institutions in biology, clinical medicine, and field delivery; and funding of governments and private foundations. Currently, it works with over 80 partners and more than 600 scientists in 34 countries and has now built the largest and most diverse portfolio of anti-malarial drug projects in history.

*Source*: www.cgiar.org; www.cimmyt.org; www.mmv.org.

## *Current coverage*

Private companies have always been involved in the provision of infrastructure services. Much of the railways network in countries, such as the United Kingdom and the United States, for instance, was built with private capital, while France is home to some of the oldest private providers of water and municipal services. However, over time most infrastructure came under state control, and it was only in the 1980s and 1990s that private involvement in infrastructure became mainstream again. Crucially, the privatisation drive went hand in hand with efforts to split up the natural infrastructure monopolies and introduce competition in sectors, such as telecoms, electric power, natural gas, railways and water. Competition, as much as private ownership, is the key factor behind the efficiency improvements observed in many privatised industries.

Starting in the United Kingdom, private participation in infrastructure spread across the globe, including developing countries and emerging markets. According to the World Bank, almost 3 800 infrastructure projects with private sector involvement were launched in developing countries between 1990 and 2006 (see Table 3.4). Through them, the private sector made investment commitments of over USD 1 trillion. While sizeable, these commitments are, however, only a small part of total investment needs.

Table 3.4. **Private sector participation in developing country infrastructure, 1990-2006**

| | | Number of projects | Project investment (USD billion) |
|---|---|---|---|
| By region | Latin America and the Caribbean | 1 202 | 435.2 |
| | East Asia and Pacific | 1 080 | 253.3 |
| | Europe and Central Asia | 740 | 206.5 |
| | Sub-Saharan Africa | 332 | 50.6 |
| | South Asia | 329 | 93.4 |
| | Middle East and North Africa | 110 | 52.3 |
| By sector | Energy | 1 481 | 321.6 |
| | Transport | 989 | 179.5 |
| | Telecom | 797 | 537.3 |
| | Water and sewerage | 526 | 52.8 |
| Total | | 3 793 | 1 091.3 |

*Source:* World Bank Private Participation in Infrastructure Database (ppi.worldbank.org).

Private infrastructure commitments in developing countries peaked in 1997, when USD 114 billion were committed in one year. The market collapsed following the Asian financial crisis and it took until 2006 before the same level of commitment was reached again. By that time, the nature of contracts had changed. The private sector had become more wary about emerging market risks and important lessons had been learned (see Kessides, 2004). As a consequence, recent contracts exhibit a more careful allocation of risks between public and private partners. Recent years have also seen the emergence of local private partners, although large international companies continue to dominate the sponsor list.

Latin America and East Asia have been the most attractive markets for private infrastructure projects in developing countries. The two regions account for about two-thirds of total commitments (Table 3.4). However, following a number of large telecoms transactions, Eastern Europe has recently gained ground (see World Bank, 2007). There are also a sizeable number of projects in Sub-Saharan Africa, but they tend to be smaller in size.

In terms of sectors, a majority of private infrastructure funding went into telecoms, where investment commitments are particularly large, and energy (mostly electric power). Between them, the two sectors account for over 80% of total investment commitments. The list does not include any projects that could be called dedicated climate protection investments, such as coastal defence structures. In fact in the water privatisation of 1989 in the United Kingdom, flood defence structures were explicitly excluded from the asset sale (see Box 3.7).

However, many PPP contracts contain implicit adaptation provisions. Either directly or indirectly the private partner generally assumes weather-related risks. Contracts based on service availability, for instance, which are common in the road sector, may penalise service interruption due to climate events. In this way, well-designed PPPs give an incentive to private operators to secure water supply in drought periods, keep roads safe in all weather, protect power lines against storm damage and safeguard port infrastructure from floods.

The World Bank estimates that about 6% of private infrastructure projects, accounting for 8% of investment commitments, are distressed or have been cancelled (Table 3.5). The failure rate is particularly high in the water sector where 10% of projects, representing a third of investment commitments, are in distress. Failure rates are also significant in Latin America, where many of the early projects took place, and in Sub-Saharan Africa. In general, projects would be more successful if: contracts are awarded competitively through a transparent tender, the risk allocation is well reasoned and fair, the contract allows for periodic reviews, and there is a clear conflict resolution mechanism.

There are no cases of contract failures triggered by climate events, such as a flood, drought or landslide, although the costs arising from such events will play a role in tariff setting and might give rise to contract re-negotiations.

### Box 3.7. **The Thames barrier**

In England and Wales control of flooding is the responsibility of the Environment Agency, an independent but government funded public body tasked with certain environmental control functions. Responsibility for flood protection includes the operation of flood defence structures. The best known of these is the Thames Barrier, the world's second largest movable flood barrier, which protects London and the Thames estuary from tidal surges and coastal flooding.

The Thames Barrier was a public project. It was undertaken by the then Greater London Council and its Department for Public Health Engineering, although design, building supervision and construction were outsourced to the private sector. Three quarters of the GBP 537 million budget (in historic prices) was raised from central government, with local taxpayers meeting the balance. Construction lasted from 1974 to 1982.

When the Greater London Council was abolished in 1986, responsibility for the operation of the barrier moved to the regional water board, the Thames Water Authority. Thames Water was privatised in 1989 and at that point responsibility for the barrier – together with other regulatory and environmental management functions – was transferred to a newly created agency, the National Rivers Authority, which in 1996 became the Environment Agency for England and Wales. The government wanted to keep responsibility for flood risk management in public hands.

*Source*: www.environment agency.gov.uk.

### Table 3.5. **Share of private infrastructure projects cancelled or in distress, 1990-2006**

| | | Percent of projects | Percent of investment |
|---|---|---|---|
| By region | Latin America and the Caribbean | 10 | 12 |
| | East Asia and Pacific | 7 | 11 |
| | Europe and Central Asia | 3 | 2 |
| | Sub-Saharan Africa | 11 | 4 |
| | South Asia | 2 | 4 |
| | Middle East and North Africa | 6 | 2 |
| By sector | Energy | 6 | 10 |
| | Transport | 6 | 11 |
| | Telecom | 5 | 4 |
| | Water and sewerage | 10 | 33 |
| Total | | 6 | 8 |

*Source*: World Bank Private Participation in Infrastructure Database (ppi.worldbank.org).

## *Relevance of PPPs for adaptation*

In applying private infrastructure schemes to climate change adaptation two main questions arise. The first question is how vulnerable current and future PPPs are to climate change and how they can be climate-proofed. The second question is whether PPP schemes are suitable to finance, build and operate dedicated climate protection schemes, such as flood barriers and coastal defences.

While it is doubtful that many of the 3 800 private infrastructure contracts contain explicit adaptation provisions, it is likely that many of them expose the private partner to weather-related risks. As such they are vulnerable to climate change. This is particularly because of the long lifespan of many infrastructures over which the impacts of climate change will become progressively significant. A subjective assessment of the climate vulnerability of existing private infrastructure projects is shown in Table 3.6. The issue is most prevalent in the case of seaports, which will have to deal directly with the impacts of sea level rise, and for water utilities, which will have to manage an increased variability in precipitation and water supply. Selected other structures will be similarly vulnerable, such as coastal power stations, roads and railway lines susceptible to landslides or floods and overhead cables that might be affected by extreme weather.

PPPs are essentially about the efficient and fair allocation of risks (and rewards) between public and private partners. Climate change is just another risk factor, albeit an increasingly important one, that has to be taken into account alongside regulatory, commercial, macroeconomic and other risks. Private infrastructure schemes should be well suited to deal with this additional risk in the sense that the institutional arrangements to analyse, mitigate and allocate it are in place. At the same time, the miscalculation of risks is one of the main reasons why PPPs fail.

The best way to avoid miscalculation and failure is to recognise climate change as an explicit risk, rather than an unexpected *force majeure*. PPP contracts should spell out explicitly and in some detail, if possible, the responsibilities and expectations of each partner. For instance, the contract may stipulate certain performance standards (say, the availability of port facilities or roads; water quality and supply standards) that are to be maintained independent of climate events or until certain climate triggers are reached. This would incentivise the private operator to undertake the necessary level of adaptation.

Table 3.6. **Vulnerability of private infrastructure projects**

| Sector | | Segment | Number of projects | Vulnerability |
|---|---|---|---|---|
| Energy | Power | Electricity distribution only | 124 | Medium |
| | | Distribution and generation/transmission | 143 | Medium |
| | | Electricity generation | 842 | Low (high on coasts) |
| | | Electricity transmission | 51 | Medium |
| | Gas | Natural gas distribution | 243 | Low |
| | | Natural gas distribution and transmission | 34 | Low |
| | | Natural gas transmission | 46 | Low |
| Telecom | Telecom | Fixed access only | 155 | Low/medium |
| | | Fixed access and other services | 205 | Low/medium |
| | | Mobile access and/or long distance | 437 | Low |
| Transport | Airports | Runway | 2 | Medium |
| | | Runway and terminal | 85 | Medium |
| | | Terminal | 31 | Low |
| | Rail | Fixed assets only | 8 | Medium |
| | | Fixed assets and freight/passenger | 67 | Medium |
| | | Freight and/or passenger | 23 | Low |
| | Roads | Bridge | 38 | Medium |
| | | Bridge and highway/tunnel | 54 | Medium |
| | | Highway | 375 | Medium |
| | | Tunnel or tunnel/highway | 9 | Medium |
| | Seaports | Channel dredging | 4 | High |
| | | Channel dredging and terminal | 20 | High |
| | | Terminal | 275 | High |
| Water | Treatment | Potable water and sewerage treatment plant | 7 | Medium/high |
| | | Potable water treatment plant | 106 | Medium/high |
| | | Sewerage treatment plant | 134 | Medium/high |
| | Utility | Sewerage collection and treatment | 7 | Medium/high |
| | | Water utility with sewerage | 223 | High |
| | | Water utility without sewerage | 49 | High |

*Source*: World Bank Private Participation in Infrastructure Database (ppi.worldbank.org) and authors' assessment.

Similarly, adaptation provisions may be reflected in the investment commitments of the private party. For instance, a private water utility may undertake to invest in new reservoirs as part of the concession agreement. In the case of greenfield investments adaptation may be incorporated in the design and construction phase of a PPP. A good example is the Confederation Bridge, a 13 km toll bridge which connects Prince Edward Island and New Brunswick in Canada. The bridge was designed, built, financed and is now operated by a private consortium. The technical specifications called for a structure that is about 1 metre higher than currently necessary to accommodate future sea level rise. The anticipatory measure added a modest CAD 10 million to the cost of the CAD 1 billion project (Smith *et al.*, 1998).

Including service standards and climate risk explicitly in the contract does not imply that the private partner will assume the costs of adaptation. The cost of these measures will be reflected in the bid price for an asset and/or higher revenue expectations. For example, private operators will expect adaptation expenditures to be recognised as a permissible cost to be passed on to end users in any tariff reviews. The cost of adaptation will (and should) be shared between the government, end-users and the private operator.

In terms of the second question – whether PPPs are suitable for dedicated climate protection schemes – there are, to our knowledge currently no private infrastructure projects that explicitly provide climate protection. However, the concept is sufficiently broad and well established to extend easily to dedicated adaptation infrastructure.

The closest existing schemes to dedicated public private adaptation projects are probably the UK PFI and some of the transport schemes. As would be the case with adaptation infrastructure, the main contribution of the private partner under PFI is in the provision of the physical infrastructure (a building, a road, or a tunnel), while the actual management of the structure involves less complexity in terms of operations, client interaction, pricing and revenue collection. Moreover, there is no commercial revenue in which private partners could participate. They are remunerated from government sources based on system availability and other performance indicators.

The relative commercial and operational simplicity should make private adaptation schemes easier to implement. However, as in all private infrastructure schemes, one has to ascertain the benefit of this arrangement over a conventional model of public finance, with design, project management, construction and maintenance carried out by private companies operating under normal procurement and contracting provisions – what in the context of the UK PFI is known as a value-for-money test.

Two generic arguments were given above in favour of such schemes – efficiency in construction and operation, and the ability to finance projects outside the government budget. Of the two, the first argument is probably less important. The same operational simplicity that makes private adaptation easier to implement also limits the potential benefit that private management can bring. Flood defences and similar projects offer limited scope for alternative designs and operations and maintenance costs are small relative to the initial capital costs. There are, thus, relatively few areas where a private operator can add value.

In contrast, the second argument is potentially very important, given the large adaptation needs in infrastructure, although fiscal sustainability constraints may impose limitations on the use of the instrument. In the absence of commercial revenues the private partner would be paid by the state and the government would commit to making these payments under the contract. These commitments, therefore, become a liability that should at least in principle be recorded in the public accounts in the same way as debt. How private infrastructure investments are treated in the fiscal accounts depends partly on their priority and economic return (see IMF, 2004a, 2004b).

These concerns point to the need for careful cost-benefit analysis and project appraisal for adaptation infrastructure. An important issue for flood defences and similar measures is the absence of a clear market demand and expression of the public's willingness to pay. While we are currently insufficiently prepared for climate change, it is easily possible that society might "over-adapt". There are countless examples of gold-plated or excessive infrastructure projects – whether publicly or privately financed.

## Concluding remarks

Humans have adapted to climate for millennia, devising behavioural patterns, technologies and socio-economic systems suitable for all climate conditions from arctic cold to desert heat. It is, therefore, tempting to assume adaptation to climate change will happen automatically. In fact, much of it will, and the measures taken will be a diverse mix of operational adjustments, investments, risk sharing, location decisions and behavioural changes at the firm, household and government levels. However, for the process to be effective a raft of policy measures will be required to prepare the ground. There is a need for incentives to adapt, as well as adequate information to do so effectively.

Adaptation policy is, therefore, about much more than raising money and meeting the costs of defensive measures. Perhaps too much of the recent adaptation debate has been about costs and who should pay. This debate is important, and least developed, highly vulnerable countries in particular will need all the financial help they can get. But it is also important that this money is spent wisely. We know from other areas of public policy – development aid, regional aid, industrial policy – that ill-conceived policies can be wasteful and in some cases counterproductive.

Since people are experienced at adapting, enlightened adaptation policy will want to tap into that expertise. It will want to promote private initiative, innovation and the unique ability of markets to turn risks into opportunities.

This chapter has provided some pointers as to how smart policy can turn private initiative into a force for adaptation. The chapter shows how a combination of markets and public policy can refine risk sharing (through innovative insurance schemes), improve natural resource management (through the creation of environmental markets) and help climate-proof infrastructure (through PPPs).

Insurance has a dual role with respect to adaptation. Access to insurance payouts can lessen the net adverse impact of climatic events on policy holders. At the same time, insurance is also an instrument for incentivising adaptations aimed at climate risk reduction. However, even this sophisticated and well-developed tool will have to be adjusted to deal with climate change. As climate damages grow and historical weather records become less reliable, insurance will become a riskier business. Risks will be exacerbated if budget constraints, inertia and cultural factors prevent people from adapting fully in the short term. As a result, insurance companies may no longer be willing to cover certain risks or may overcharge for coverage. It is likely that this will particularly affect poor households and poor countries, where uneven insurance cover is already an issue. Public policy measures will be needed to overcome these market imperfections. They could for instance take the form of publicly funded adaptation measures to bring risks down to an acceptable level. Alternatively, risks may be shared between commercial insurers and the public sector. In this case the government could subsidise the most extreme layer of risk without creating perverse incentives and impeding adaptation decisions that might be needed to respond to more systemic climate risks. Broader use of premium subsidies, however, may reduce incentives to move away from activities that become progressively less viable under the changing climate.

The need for sound management of natural resources will grow in importance under climate change. Water resources, forests and other ecosystems are already under considerable stress from pollution, overexploitation and mismanagement. Without adequate measures, climate change risks pushing some systems over the limit. Ill-defined property rights and under-pricing are at the root of poor resource management. Economic instruments, such as cost-based pricing (including environmental costs) and environmental markets can help to overcome these market imperfections.

Although still in their infancy, there is growing experience with such instruments in practice, and they can help to promote adaptation behaviour. From an adaptation point of view environmental markets and pricing – for water, forests or other ecosystem services – serve two main purposes. First, they reduce baseline stress, making systems more resilient. Second, they help to monetise the adaptation services provided by ecosystems, for example coastal protection in the case of mangroves and wetlands. For the first purpose it is not necessary to adjust market mechanisms specifically for adaptation. For the second purpose adjustments will be needed to internalise fully the adaptation benefits of natural systems. In addition, there will have to be a reliable demand willing to pay for these services.

As Chapter 2 has shown, building climate-proof infrastructure is likely to be the most expensive part of adaptation and will put considerable strain on the administrative and financial capacity of governments. Experience elsewhere shows that well-designed PPPs can help to overcome operational constraints, enhance performance and accelerate investment. In applying PPP schemes to adaptation two main questions arise. The first is how PPPs need to be adjusted to deal with climate change. PPPs are all about the allocation of risks. As such they should be well suited to deal with an additional, if as yet ill-defined risk. Many PPPs already contain implicit adaptation provisions. However, climate change has to be recognised as an explicit rather than unexpected risk. The PPP contracts need to spell out explicitly the responsibilities and expectations of each partner, including in terms of adaptation. The second question is whether PPP schemes are suitable to finance, build and operate dedicated climate protection schemes, such as flood barriers and coastal defences. There are as yet no the dedicated adaptation PPPs. However, the concept is sufficiently broad and well established to extend to dedicated adaptation infrastructure. In addition, PPPs may play a role in R&D and the search for better adaptation technologies.

Setting up insurance schemes, environmental markets, PPPs and similar schemes will be a considerable challenge to public policy. Much further work is needed to refine the concepts, work out details and set up pilot schemes. A key ingredient will be good climate information at the local level – a condition that is in most cases not yet fully met. Preparatory work will also be required to build technical and institutional capacity, particularly (but not only) in a developing country context, and to reach out to stakeholders. Adaptation to climate change as a public policy challenge has only just emerged.

# *References*

Agroasemex (2006a), "The Mexican Experience in the Development and Operation of Parametric Insurances Applied to Agriculture", working paper.

Agroasemex (2006b), "The Mexican Experience in the Development and Operation of Parametric Insurance Oriented to Livestock", working paper.

Alderman, H. and T. Haque (2007), "Insurance against Covariate Shocks: The Role of Index-Based Insurance in Social Protection in Low-Income Countries of Africa", Working Paper 95, Africa Region Human Development Department, World Bank, Washington, DC, March.

ADB (Asian Development Bank) (2001), *Water for All – The Water Policy of the Asian Development Bank*, ADB, Manila.

Barnett, B. J. and O. Mahul (2007), "Weather Index Insurance for Agriculture", *American Journal of Agricultural Economics* 89(5), pp. 1241-1247.

Barnett, B. J., C. B. Barrett and J.R. Skees (2008), "Poverty Traps and Index-Based Risk Transfer Products", World Development, forthcoming.

Bentley, J. (2007), "Testing the Limits of Trade", *Environmental Finance*, July-August.

Briscoe, J. (1996), "Water as an Economic Good: The Idea and What it Means in Practice", paper presented at the World Congress of the International Commission on Irrigation and Drainage, Cairo, September, World Bank, Washington, DC.

Burton, I. (1996), "The Growth of Adaptation Capacity: Practice and Policy", in "Adapting to Climate Change: An International Perspective", in J.B. Smith, N. Bhatti and G. Menzhulin (eds.), *Adapting to Climate Change: Assessments and Issues*, Springer Verlag, Berlin and New York.

Burton, I., E. Diringer and J. B. Smith. (2006), "Adaptation to Climate Change: International Policy Options", paper prepared for the Pew Center on Global Climate Change.

Cárdenas, V.S. (2006), "Developmental Challenges in Using Catastrophic Bonds for Disaster Risk Management: The Mexican Experience", presented at the Sixth DPRI-IIASA Forum on Integrated Disaster Risk Management, Istanbul, Turkey, 13-17 August.

Carter, M. R., S.R. Boucher and C. Trivelli (2007), "Concept Note: Area-Based Yield Insurance Pilot Project for Peruvian Coastal Agriculture", BASIS Research Program, December.

Easter, K.W. and S. Zekri (2003), "Reform of Irrigation Management and Investment Policy in African Development", paper presented at Pre-IAAE Conference on African Agricultural Economics, Bloemfontein, South Africa, 13-14 August.

EBRD (European Bank for Reconstruction and Development) (2004), "Transition Report 2004 – Infrastructure", EBRD, London.

EBRD (2007), "Transition Report 2007 – People in Transition", EBRD, London.

Fankhauser, S. and S. Tepic (2007), "Can Poor Consumers Pay for Energy and Water? An Affordability Analysis for Transition Countries", *Energy Policy* 35(2), pp. 1038-1049.

Hartwich, F., *et al.* (2007), "Building Public–Private Partnerships for Agricultural Innovation in Latin America: Lessons from Capacity Strengthening", IFPRI Discussion Paper 00699, International Food Policy Institute, Washington, DC, www.ifpri.org/pubs/dp/IFPRIDP00699.pdf.

Ibarra, H. and J. Syroka (2006), "Case Studies for Agricultural Weather Risk Management", *Risk Management in Agriculture for Natural Hazards*, ISMEA, Rome.

IMF (Internatinoal Monetary Fund) (2004a), "Public Private Partnerships", paper prepared by the Fiscal Affairs Department, March, IMF, Washington, DC.

IMF (2004b), "Public Investment and Fiscal Policy", paper prepared by the Fiscal Affairs Department, March, IMF, Washington, DC.

IPCC (Integovernmental Panel on Climate Change) (2001), "Climate Change 2001: Impacts, Adaptation and Vulnerability", Working Group II Contribution to the *Third Assessment Report of the Integovernmental Panel on Climate Change*, "Chapter 18: Adaptation to

Climate Change in the Context of Sustainable Development and Equity", Cambridge University Press, Cambridge, pp. 877-912.

IPCC (2007), "Climate Change 2007: Impacts, Adaptation and Vulnerability", Working Group II Contribution to the *Fourth Assessment Report of the Intergovernmental Panel on Climate Change*, "Chapter 17: Assessment of Adaptation Practices, Options, Constraints and Capacity", Cambridge University Press, Cambridge, pp. 717-743.

IPTRID (International Programme for Technology and Research in Irrigation and Drainage) (2001), "Case Studies on Water Conservation in the Mediterranean Region", Food and Agriculture Organization, Rome.

Isom, W.R. (2007), "Traditional Catstrophic Reinsurance and CAT Bonds", presented at expert meetings of the Catastrophe Insurance and Weather Risk Management Markets for National Meteorological and Hydrological Services, WMO Headquarters, Geneva, Switzerland, 5-7 December.

Jetté-Nantel, S. and S. Agrawala (2007), "Climate Change Adaptation and Natural Hazards Management", in S. Agrawala (ed.), *Climate Change in the European Alps: Adapting Winter Tourism and Natural Hazards Management*, OECD, Paris, pp. 61-93.

Kerf, M. and A.K. Izaguirre (2007), "Revival of Private Participation in Developing Country Infrastructure: A Look at Recent Trends and their Policy Implications", Grid Lines Note No. 16, World Bank, Washington, DC.

Kessides, I.N. (2004), "Reforming Infrastructure: Privatization, Regulation, and Competition", Oxford University Press, Oxford.

Landell-Mills, N. and I.T. Porras (2002), *Silver Bullet or Fools' Gold – A Global Review of Markets for Forest Environmental Services and their Impact on the Poor,* International Institute for Environment and Development (IIED), London, www.iied.org/pubs/pdfs/9066IIED.pdf.

Lecocq, F. and Z. Shalizi (2007), *Balancing Expenditures on Mitigation of and Adaptation to Climate Change: An Exploration of Issues Relevant to Developing Countries*, World Bank, Washington, DC, p. 45.

Leftley, R. and S. Mapfumo (2006), "Effective Micro-Insurance Programs to Reduce Vulnerability", paper commissioned for the Global Microcredit Summit Campaign, Nova Scotia, Canada, 12-16 November, www.opportunity.net/publications/pub.reduceVulnerability.asp.

Mahul, O. and J.R. Skees (2005), “Managing Agricultural Catastrophic Risk at the Country Level: The Case of Livestock Mortality Risk in Mongolia”, working paper, World Bank, April.

Mahul, O. and J. R. Skees (2007), “Managing Agricultural Risk at the Country Level: The Case of Index-Based Livestock Insurance in Mongolia”, Policy Research Working Paper WPS4325, World Bank, Washington, DC, 1 August.

Manuamorn, O.P. (2006), “Review of Weather Index Insurance Project Developments in Thailand”, presentation at the “Weather Index Insurance: Weather Risk Management for Agriculture in Thailand” seminar, organised by the World Bank Office Bangkok and the Commodity Risk Management Group (CRMG) of the World Bank, Bangkok, Thailand, 13 October.

Manuamorn, O. P. (2007), “Scaling up Microinsurance: The Case of Weather Insurance for Smallholders in India”, Agriculture and Rural Development Discussion Paper 36, World Bank, Washington, DC.

Mohanty, N. and S. Gupta (2002), “Breaking the Gridlock in Water Reforms through Water Markets: International Experience and Implementation Issues for India”, Julian L. Simon Centre for Policy Research, Liberty Institute, New Delhi.

O’Hearne, B. (2007), “Case Study No. 3: Millennium Village Project”, presented at expert meetings of the Catastrophe Insurance and Weather Risk Management Markets for National Meteorological and Hydrological Services, WMO Headquarters, Geneva, Switzerland, 5–7 December.

Pagiola, S.P., *et al.* (2004), “Paying for Biodiversity Conservation in Agricultural Landscapes”, Environment Department Paper No. 96, World Bank, Washington, DC.

Perrot-Maître, D. (2006), “The Vittel Payments for Ecosystem Services: A “Perfect” PES Case?”.

Skees, J.R. and A. Enkh-Amgalan (2002), “Examining the Feasibility of Livestock Insurance in Mongolia”, Policy Research Working Paper 2886, Rural Development and Natural Resources Sector Unit East Asia and Pacific Region, World Bank, 17 September.

Skees, J.R. and A.J. Leiva (2005), “Analysis of Risk Instruments in an Irrigation Sub-Sector in Mexico”, report prepared for the Inter-American Development Bank Technical Cooperation Program and IDB-Netherlands Water Partnership Program, 30 June.

Skees, J.R., B.J. Barnett and B. Collier (2008), "Agricultural Insurance – Background and Context for Climate Adaptation Discussions", consultant report to the OECD.

Skees, J.R., J. Hartell and A.G. Murphy (2007), "Using Index-Based Risk Transfer Products to Facilitate Micro Lending in Peru and Vietnam", *American Journal of Agricultural Economics* 89(5), pp. 1255–1261.

Skees, J.R., U. Hess and H. Ibarra (2002), "Crop Disaster Assistance in Ukraine: Issues, Alternatives, and Consequences", World Bank Rural Finance Project P076553, December.

Skees, J.R., *et al.* (2001), "Developing Rainfall-Based Index Insurance in Morocco", Policy Research Working Paper 2577, World Bank, Washington, DC, April.

Skees, J.R., *et al.* (2006), "Index Insurance for Weather Risk in Low Income Countries", USAID Microenterprise Development (MD) Office, USAID/DAI Prime Contract LAG-I-00-98-0026-00 BASIS Task Order 8, Rural Finance Market Development.

Smith, J.B., *et al.* (1998), "Proactive Adaptation to Climate Change: Three Case Studies on Infrastructure Investments", Working Paper D-98/03, Institute for Environmental Studies, Vrije Universiteit, Amsterdam.

Stoppa, A. and U. Hess (2003), "Design and Use of Weather Derivatives in Agricultural Policies: the Case of Rainfall Index Insurance in Morocco", paper presented at the international conference, "Agricultural Policy Reform and the WTO: Where Are We Heading?", Capri, Italy, 23-26 June.

Swiss Re (2007), "Swiss Re Launches Climate Adaptation Development Program Providing Financial Protection Against Weather Risk in Emerging Countries", press release, 27 September.

Syroka, J. (2007), "Weather Insurance for Small and Medium Farmers: Building a Weather Risk Market in Central America", WRMA Annual Meeting, Miami, Florida, 9–11 May.

Syroka, J. and R. Wilcox (2006), "Rethinking International Disaster Aid Finance", *Journal of International Affairs* 59(2), pp. 197–214.

UNECE (United Nations Economic Commission for Europe) (2006), "Payments for Ecosystem Services in Integrated Water Resources Management", document ECE/MP.WAT/2006/5, UNECE, Geneva.

UNEP (United Nations Environment Programme) (2006), "Developing International Payments for Ecosystem Services: A Technical Discussion", UNEP Economics and Trade Branch, Geneva.

USAID (United States Agency for International Development) (2006), "Hedging Weather Risk for Microfinance Institutions in Peru", report prepared by GlobalAgRisk, Inc., under USAID/DAI Prime Contract LAG-I-00-98-0026-00 BASIS Task Order 8, Rural Finance Market Development, November.

Vidal, A, *et al.* (2001), "Success Stories in Water Conservation in the Mediterranean Region: A Review of Technologies and Enabling Environment for Water Conservation - Lessons Learnt", *GRID* 17, February.

Wenner, M. (2007), "New Developments in Agricultural Insurance: A Latin American and Caribbean Perspective", presented at Third Annual Microinsurance International Conference, Mumbai, India, 13–15 November.

World Bank (2007), "PPI in Developing Countries in 2006", results from the PPI Project Database, World Bank, Washington, DC, November.

Wunder, S. (2005), "Payments for Environmental Services: Some Nuts and Bolts", CIFOR Occasional Paper No. 42, Center for International Forestry Research, Jakarta.

# List of Abbreviations

| | |
|---|---|
| ADB | Asian Development Bank |
| CDM | Clean Development Mechanism |
| CEE | Central and Eastern Europe |
| CGE | Computable General Equilibrium |
| EBRD | European Bank for Reconstruction and Development |
| EC | European Commission |
| EEA | European Environment Agency |
| ENSO | El Niño Southern Oscillation |
| FDI | Foreign Direct Investment |
| FONDEN | *Fondo para Desastres Naturales* |
| fSU | former Soviet Union |
| GDI | Gross Domestic Investment |
| GDP | Gross Domestic Product |
| GHG | Greenhouse gas |
| GNP | Gross National Product |
| IMF | International Monetary Fund |
| IPCC | Intergovernmental Panel for Climate Change |
| LDCs | Least Developed Countries |
| MAF | Mean annual flow |
| MDB | Murray Darling Basin |
| MENA | Middle East and North Africa |
| MPCI | Multi-peril crop insurance |
| NAPA | National Adaptation Programmes of Action |
| NASFAM | National Smallholder Farmers' Association of Malawi |
| NGO | Non-governmental organisation |
| NOAA | National Oceanic and Atmospheric Administration (United States) |
| ODA | Official Development Assistance |
| PES | Payment for ecosystem or environmental services |
| PPP | Public Private Partnership |
| PFI | Private Finance Initiative |
| R&D | Research and development |
| ROH | Risk of hunger |
| SRES | Special Report on Emission Scenarios (of IPCC) |
| SSA | Sub-Saharan Africa |

| | |
|---|---|
| UNDP | United Nations Development Programme |
| UNECE | United Nations Economic Commission for Europe |
| UNFCCC | United Nations Framework Convention on Climate Change |
| USGS | United States Geological Survey |
| WB | World Bank |
| WFP | World Food Programme |
| WHO | World Health Organization |
| WUAs | Water user associations |
| WWF | World Wildlife Fund |

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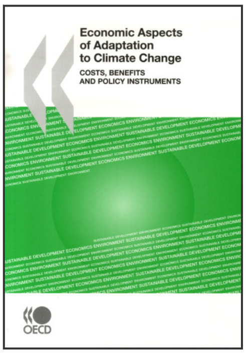
## Boxes



## Tables



## Figures

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