Executive Summary

Adaptation to climate change is now widely recognised as an equally important and complementary response to greenhouse gas (GHG) mitigation in addressing climate change. Adaptation consists of deliberate actions undertaken to reduce the adverse consequences, as well as to harness any beneficial opportunities. A wide range of adaptation measures can be implemented in response to both observed and anticipated climate change. Such measures include altering farming practices and crop varieties, building new water reservoirs, enhancing water use efficiency, changing building codes, investing in air-conditioning, and constructing sea walls. Adaptation measures are undertaken both by public and private actors through policies, investments in infrastructure and technologies, and behavioural change. How much adaptation might cost, and how large its benefits might be, are issues that are increasingly relevant both for on-the-ground projects, as well as in a global context where trade-offs might need to be considered between the costs of climate policies and the residual damages resulting from climate change.

This report provides a critical assessment of adaptation costs and benefits in key climate sensitive sectors, as well as across sectors at the sectoral, national and global levels. It also moves the discussion beyond cost estimation to examining market and regulatory mechanisms that can be used to incentivise adaptation actions. Such mechanisms have so far received little attention in the context of adaptation.

Adaptation efforts need to rest on a sound economic basis

From an economic perspective, adaptation could be evaluated in terms of whether, and by how much, the benefits of such actions exceed the costs incurred. In particular, estimates of adaptation costs and benefits are relevant at two levels. First, adaptation costs and benefits are relevant for actors directly exposed to particular climate risks who need to make decisions about whether, how much, and when to invest in adaptation. These actors could include individuals and households, farmers, project managers, and

sectoral planners. Second, at the national and global level, cost estimates can be used to establish aggregate adaptation "price tags" that would then need to be met through international, domestic, and private funding sources.

There are, however, significant analytical and policy challenges associated with estimating adaptation costs and benefits. One reason is the nebulous nature of many adaptation actions, which are often embedded within responses undertaken to a broader set of social and environmental stimuli. It might, therefore, not be feasible to cost the climate component of such decisions that are also simultaneously conditioned by a whole range of other, and often more influential, factors. Adaptation costs may also increase several-fold if, in addition to measures that directly reduce climate damages, measures to improve baseline "adaptive capacity" are also included within the purview of adaptation. Uncertainty about the specific effects of climate change will also influence adaptation costs and benefits, as will the timing of the actions that are undertaken. There might also be significant differences between direct and economy-wide consequences of adaptation measures. These considerations, therefore, need to be borne in mind while interpreting particular empirical estimates of adaptation costs and benefits.

Sectoral adaptation costs and benefits estimates are available, but their coverage is uneven

There is a relatively large amount of information available about adaptation costs at the sectoral level, although it is unevenly distributed across sectors. In particular, there is a significant body of literature accumulated since the early 1990s on assessing adaptation in coastal zones, including on the costs and benefits of such measures. These studies reveal that the cost estimates for optimal levels of protection are typically relatively modest in normalised terms, although in absolute terms these still represent a significant investment. In the agricultural sector, studies have focused on quantifying the benefits of adaptation strategies and provide limited information on the costs of such measures. A general finding from the global-level studies is that relatively modest adaptation measures can significantly offset declines in projected yield as a result of climate change. However, adaptation benefits will vary depending on crop type and may not translate equally to all regions. In the case of coastal zones and agriculture there is also fairly comprehensive geographical coverage. By contrast, the information on costs of adaptation is much more limited and diffuse for the water resources, energy, infrastructure, tourism and public health sectors and limited largely to developed country contexts. Such information is also very context specific making broader generalisations difficult.

Some adaptations can be implemented at low cost but others, such as infrastructural measures, will require significant investment

Sectoral studies have shown that in some sectors some adaptation actions can lead to high benefit-cost ratios and/or be implemented at low cost. For example, farm level adjustments, which are assumed to cost very little, can lead to significant benefits in terms of offsetting damages. This is also the case for other behavioural adaptations, such as enhanced water use efficiency. On the other hand, many adaptations inevitably involve "hard" or infrastructural measures, such as water storage reservoirs and desalinisation and waste water treatment facilities in the case of the water sector. Likewise, infrastructural solutions are prevalent in coastal zones, with coastal protection measures, such as dykes and sea walls, representing the main adaptation options considered. Infrastructure adaptation costs are also key in systems that are already critically at risk from immediate climate change impacts, such as high latitude and high altitude systems.

Adaptation costing studies have tended to focus more on these "hard" adaptation measures, as they are easier to cost than behavioural and policy measures. This may lead to a bias towards structural measures and a neglect of potentially critical "soft" measures needed to facilitate adaptation (such as better land use planning), and lead to inappropriate and costly adaptation actions. It may also result in overestimation of adaptation costs. On the other hand, other aspects of existing studies may actually result in underestimation of the costs of adaptation. For example, costing studies in coastal zones typically only consider adaptation to gradual sea level rise and do not consider storm surges or extreme scenarios of sea level rise. The consideration of extreme events in addition to changes in mean conditions is likely to significantly increase the costs of adaptation. For these reasons it is important that not too much emphasis is placed on particular estimates of costs of adaptation strategies, as such a focus could distort policy priorities.

Global studies of adaptation costs are also available, but face very serious limitations

Until recently there were no empirical estimates of the global costs of adaptation across multiple sectors, but five assessments have explicitly confronted this issue since mid-2006. These studies suggest that adaptation to climate change at the global level will cost several USD billion per year. While potentially relevant for the international discussion on adaptation and its financing, existing global multi-sectoral estimates face serious limitations. In particular, the results are quite sensitive to the assumptions

made with regard to the exposure of assets and investments to climate change and the costs of "climate-proofing" them. Very little or no analytical information is currently available on either of these parameters and, therefore, the assumptions that are made become particularly critical, given the very large magnitude of baseline investments to which these percentages are applied. Further, in most cases the estimates do not have a direct attribution to specific adaptation activities, nor are the benefits of adaptation investments articulated. There are also issues of double counting, and scaling up to global levels from a very limited (and often very local) evidence base. Successive studies have also tended to stack upon the assumptions made in preceding studies and the results are consequently not truly independent. Therefore, the "consensus", even in order of magnitude terms, is premature. For all these reasons "headline" global adaptation cost numbers can be seriously misleading if adequate attention is not paid to the assumptions that underlie particular empirical estimates.

Adaptation policy is about much more than costing and financing, establishing incentives is also critical

While the policy debate has focused on the cost of adaptation, ways to raise public adaptation funding, and allocation of adaptation costs, much less attention has been given to the role of market and regulatory mechanisms in facilitating adaptation. This is particularly 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 provide public benefits, such as protection of coastal areas from sea level rise, many others will offer more private benefits that accrue to individuals or firms, or to a consortium of such actors. In theory, the latter set of actions should be autonomous. 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. 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 of 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. Policy instruments need to be put in place to catalyse such engagement and to ensure that it leads to the desired outcomes. These instruments can be directed at using markets, creating markets, regulation and legal

arrangements, and engaging the public. A range of policy instruments are relevant to adaptation in many sectors, including insurance schemes, price signals/markets, financing schemes via Public Private Partnerships (PPPs), regulatory incentives, and research and development incentives. Insurance schemes, price signals and environmental markets, and PPPs for infrastructure as well as research and development are explored further in this report.

Insurance can incentivise adaptation if premiums are well designed; it is, however, not a panacea

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 reducing climate risks. Properly set insurance premiums can, in principle, send appropriate signals to policy holders to undertake adaptation measures to reduce exposure to various risks, including those posed by climate change. On the other hand, poorly designed premiums that do not adequately reflect the underlying risk can actually impede adaptation or even promote maladaptation. Insurance 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 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 assessing risk and spreading it away from those affected, while encouraging those at risk to adapt to the new environment. Insurance can play a prominent role in any adaptation strategy, covering risks, such as crop failure, snow coverage and the impact of freak weather events (*e.g.* floods, storms, hurricanes and heat waves). However, there are a number of reasons why its impact on adapting to climate change may be limited. First, as long as climate impacts are uncertain, insurance companies 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. Third, insurance cover is by no means universal. It is especially patchy among poor households and in poor countries. Public policy measures will likely be needed to overcome these market imperfections. For example, they may take the form of publicly funded adaptation measures to bring risks down to an acceptable level. Alternatively, government could subsidise the most extreme layer of risk to cover low probability high consequence events. Public policy should not, however, subsidise systemic risks, as it may reduce incentives to move away

from activities that become progressively less viable under the changing climate.

Price signals and environmental markets can be used to promote adaptation actions but may require adjustments to internalise adaptation benefits

Climate change will add to the pressures and "baseline" stress factors already affecting natural resources, such as water, forests and other ecosystems. Baseline stress from pollution, overexploitation and mismanagement has many causes, but at the root of it is the fact that property rights over natural resources are ill defined and their services are not valued properly in the market. 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 (*e.g.* through environmental charges) or by creating environmental markets. There is vigorous discussion about the extent to which these economic mechanisms are actually effective in practice. There are questions about social outcomes of trading schemes, with issues about the equity of access to markets and the potential market dominance of important players. The report focuses on water pricing, water markets and payment for ecosystem or environmental services (PES) and how they can encourage and promote adaptation behaviour. From an adaptation point of view environmental markets and pricing – for water, forests or other ecosystem services – serve two main purposes. They reduce baseline stress (making systems more resilient) and they allow to internalise, or give value to, the adaptation benefits provided by ecosystems, for example in terms of coastal protection. 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. For the second purpose, adjustments in the design of environmental markets may be needed in order to monetise the adaptation benefits of ecosystems and ensure allocative efficiency of those markets.

Public private partnerships can help provide infrastructure for adaptation and help "climate-proof" existing infrastructure

Adaptation will put a considerable strain on government resources. Faced with either operational or financial constraints (or both), governments often look to the private sector to enhance their ability to provide public

services. Well-designed PPPs can help overcome operational constraints, enhance performance and accelerate investment. 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. In applying private infrastructure schemes to climate change adaptation two main questions arise. The first question is how current and future PPPs can be adjusted to climate-proof the investments they make. The second is whether these schemes are suitable to finance, build and operate dedicated climate protection schemes, such as flood barriers and coastal defences. Regarding the first question, private infrastructure schemes should be well suited to deal with this additional risk so far as the institutional arrangements to analyse, mitigate and allocate it are put in place. At the same time, miscalculation of risks is one of the main reasons why PPPs fail. It would, therefore, be wise to build responsibility for adaptation into the contracts to the extent possible. This could, for example, take the form of technical specifications to climate-proof a structure or – perhaps better – clear performance standards that incentivise the private operator to invest in adaptation. Regarding the second question, there are 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. A potential advantage of PPP schemes is that they provide the ability to finance projects outside the government budget. This is potentially very important given the large adaptation needs in infrastructure, although fiscal sustainability constraints may impose limitations on the use of the instrument. There is, therefore, a need for careful cost-benefit analysis and project appraisal for adaptation infrastructure.

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

Table of Contents

Boxes

Tables

Figures