

Climate Compatible Development in the Infrastructure Sector

**An overview of the opportunities and challenges at the nexus of climate
change, infrastructure and development**

Lily Ryan-Collins, Karen Ellis & Alberto Lemma

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List of Acronyms

CBA	Community-Based Adaptation
CCS	Carbon Capture and Storage
CDM	Clean Development Mechanism
CER	Certified Emission Reduction
CTF	Clean Technology Fund
DAC	Development Assistance Committee
FDI	Foreign Direct Investment
FIT	Feed-in Tariff
GDP	Gross Domestic Product
GEF	Global Environment Facility
GHG	Greenhouse Gas
ILO	International Labour Organisation
IPCC	Intergovernmental Panel on Climate Change
LAC	Latin America and the Caribbean
LDC	Least Developed Country
LDCF	Least Developed Countries Fund
LIC	Low-Income Country
MIC	Middle-Income Country
NAPA	National Adaptation Programme of Action
NGO	Non-Governmental Organisation
ODA	Overseas Development Assistance
OECD	Organisation for Economic Cooperation and Development
R&D	Research and Development
REDD	Reducing Emissions from Deforestation in Developing Countries
SCCF	Special Climate Change Fund
SME	Small and Medium Enterprises
SIDS	Small-Island Developing States
TNA	Technology Needs Assessment
UNFCCC	United Nations Framework Convention on Climate Change

Overview

Key Points

- Infrastructure policymakers and practitioners have a crucial role to play in meeting the challenge of climate change in the developing world. This applies both to **mitigation**, i.e. reducing greenhouse gas emissions in ways that facilitate growth and sustained poverty reduction; and to **adaptation**, i.e. protecting vulnerable populations from the impacts of climate change.
- Three key challenges are: raising the necessary finance; developing and transferring technology; and developing the capacity of governments to formulate and implement climate change policy.
- But climate change has also created developmental opportunities in the infrastructure sector, including access to new sources of finance, the potential for green job creation, and profiting from synergies between climate change initiatives and developmental priorities.
- The analysis in this report suggests that donor climate-related infrastructure funding may be excessively skewed towards mitigation at the cost of adaptation, and that mitigation funding may be excessively skewed towards the energy sector at the cost of the buildings sector.

Climate change is recognised as one of the most significant threats to development during the 21st Century and beyond. Infrastructure and the engineering profession have a crucial role to play in efforts to

reduce emissions in order to stabilise global warming, and to adapt to the climatic changes that have become inevitable.

Action in the infrastructure sector is urgent, as infrastructure assets have a long life span and rates of infrastructure investment are high in many developing countries. Inaction could lead to countries becoming 'locked-in' to high-carbon growth paths during a period which is critical for the climate, and developing infrastructure stocks that are not suited to new climatic conditions. Such an outcome would compromise developmental goals.

Given the high stakes and the urgency of action, it could not be more important at the current time to gain an improved understanding of the challenges and opportunities at the nexus of climate change, infrastructure and development. That is the aim of this report, approached through the following objectives:

1. Describe the transformation required in the infrastructure sector to promote low-carbon growth and climate-resilient development.
2. Identify the key challenges to achieving this transition within the required timeframe in the developing world, and the strategies that have been developed to date to meet these challenges. Take preliminary steps towards identifying the further action likely to be required.
3. Explore potential developmental opportunities associated with international and national efforts at mitigation and discuss, in general terms, how they can be realised.

4. Identify approaches to maximising the developmental outcomes of adaptation investment in the infrastructure sector.
5. Analyse climate-related infrastructure funding flows from donors and the Clean Development Mechanism (CDM), compare these with estimated needs, and draw preliminary conclusions from the trends observed.
6. Develop an improved understanding of the reality of climate change policy development in the infrastructure sector by studying the infrastructure-related low-carbon growth strategies of nine countries.
7. Draw conclusions and make recommendations based on the above, and identify priority areas for further study.

The report structure reflects these seven objectives, preceded by a brief introductory section covering some fundamental concepts around climate change and the relationship between climate change and development.

The definition of infrastructure used here is broad and encompasses the OECD definition of economic infrastructure to include transport, energy, information and communication technology, irrigation, drinking water and sanitation (OECD/DAC, 2006) as well as the UK Institution of Civil Engineer's definition of civil engineering infrastructure which covers bridges, roads, canals, dams, tall buildings and other large structures (ICE, 2010).

Climate change

The Intergovernmental Panel on Climate Change (IPCC) has predicted that the earth will be between 1.8°C - 4°C warmer by the end of the 21st Century compared to the end of the 20th Century. The principal cause of global warming is human activity that releases greenhouse gases into the atmosphere, particularly the burning of fossil fuels. Two degrees centigrade is widely considered the maximum temperature increase to avoid irreversible damage to the global climate and ecosystems. For the world to have a 50% chance of keeping within the 2°C ceiling, global emissions of greenhouse gases need to peak by 2020 at the latest, be cut by at least 50% of their 1990 levels by 2050, and continue to decline thereafter (EC, 2010). It now seems highly unlikely that this will be achieved. The severity of impacts will depend on the point at which temperatures are stabilised, but projected impacts include increased precipitation, more frequent extreme weather events, flooding, drought, sea level rise, increased risk of species extinction and the collapse of ecosystems, and increased disease burden at lower latitudes.

Responses to climate change are classified as *mitigation* or *adaptation*. Mitigation refers to efforts to reduce current or future emissions. Adaptation refers to initiatives or measures to reduce the vulnerability of natural and human systems against climate change effects (IPCC, 2007b).

The key economic tool in reducing emissions is creating a price for carbon, thereby incentivising a change in behaviour through market forces. Emissions trading (whereby emissions are capped and emissions permits are issued to companies which can then be traded) and

taxing carbon represent two important ways to establish a carbon price. Thirty-seven countries and the EU have voluntarily agreed to binding emissions reductions targets through the Kyoto Protocol. International negotiations on more widespread emissions limitations are ongoing under the United Nations Framework Convention on Climate Change (UNFCCC).

Climate change and development

Developing countries bear little historic responsibility for the emissions that are causing climate change¹, but stand to suffer the most severe consequences, for three main reasons. Firstly, climatic impacts will be more acute at lower latitudes where most developing countries are located. Secondly, developing countries are more dependent on climate-sensitive sectors such as agriculture and fishing. Finally, poorer countries have lower capacity to adapt due to their weaker institutions, lower human and financial capital, and constrained access to technology and credit (Burton et al, 2006). Within developing countries it is those individuals in the lowest income brackets, or who experience heightened vulnerability for other reasons, that are most vulnerable to the impacts of climate change (World Bank, 2010a).

Poorer countries also face risks to their opportunities for economic growth as a result of global efforts to stabilise the atmospheric concentration of greenhouse gases (GHGs). Historically, economic growth has been closely linked with increased GHG emissions.

¹ Today's high-income countries have generated about 80% of past fossil-fuel based emissions, despite having only 15% of the global population (UN-DESA, 2009d).

Developing countries will need to break this link if they are to experience rapid growth in a carbon-constrained world; they will need to 'leapfrog' the polluting production methods used by the developed world and move straight to low-carbon growth paths. But there are massive financial, technological and capacity challenges associated with achieving this.

The perspectives and priorities of developing countries in relation to climate change mitigation and adaptation differ depending on their stage of economic development (among other factors). In general, less developed countries will place greater emphasis on adaptation, at least in the short-term. This is because least-developed or low-income countries have relatively low emissions due to their lower levels of industrialisation, while at the same time many of them are highly vulnerable to the impacts of climate change. More industrialised developing countries face the prospect of emissions limitations (agreed in international negotiations) in the relatively near future so will need to devote significant resources to mitigation in order to enable continued rapid growth, while also taking measures to cope with climate change impacts.

Despite these well-warranted differences in perspective, many would argue that it is in the best interests of lower-income countries to integrate mitigation considerations into policy decisions at the earliest possible stage (Mitchell & Maxwell, 2010). This would provide access to the opportunities associated with mitigation discussed later in this report, and support the development of a growth trajectory that is sustainable in the long term.

It is important to recognise that institutional, capacity and financial limitations may make this difficult to achieve in many countries.

Climate change has far-reaching implications for development as described above, but the economic and social impacts of global warming will depend not only on progress in the international arena, but also critically on the developmental paths that countries adopt. A broad range of developmental choices - in which infrastructure policy plays a key role - impact countries' capacity to cope with emissions reductions and climate impacts. These include geographical distribution of activities, urban design and transport infrastructure, land use, and energy security (Sathaye et al., 2007).

How Climate Change will affect the Infrastructure Sector in the Developing World

Mitigation

Over half of global GHG emissions result from the construction and use of infrastructure assets, so progress in reducing infrastructure-related emissions is crucial to global efforts to prevent irreversible damage to the global climate and ecosystems. Key infrastructure sectors for mitigation are energy, transport and buildings. The manufacture of cement and steel also makes up a significant share of global emissions.

While all sectors play an important role, it is a transition in the energy sector that will be at the core of a strategy to meet climate change and developmental goals (UN-DESA, 2009f). Efforts to achieve this transition are grouped into three categories: reducing demand; switching to cleaner fuels; and carbon capture and storage (Fisher et al., 2007). Many of the technologies that will be required to

reduce emissions from energy production do not yet exist or are still under development, so the rate of technological development in the energy sector will directly influence the ability of countries to grow while restricting their carbon emissions (World Bank, 2010d).

Of the four sectors listed above, it is the buildings sector that has the greatest potential for rapid and cost-effective emissions reductions. The majority of the technologies required to make the transition already exist, and most interventions will result in improved operating efficiency and thus an overall cost-savings during the building's lifetime (Levine et al., 2007). However, action is currently severely sub-optimal due to market and information barriers, low awareness amongst landlords and tenants, limited access to finance, and the fragmentation of the construction industry (*ibid*).

In the transportation sector, the magnitude of emissions depends on three factors; the design of vehicles, the fuel they use, and the transport infrastructure provided (World Bank, 2010a). Cleaner fuel sources and more efficient engines play a key role, but achieving emissions reductions on the scale required will also depend upon the development of infrastructure that enables 'modal shifts' to forms of transport that produce less emissions and supports the minimisation of the number and length of journeys. Technical and urban planning solutions will be required to reduce emissions without compromising economic growth and other developmental goals.

A high proportion of the world's cement and steel production takes place in the developing world, but in many countries production facilities are outdated and inefficient.

Technology transfer and carbon capture and storage will play a key role in reducing emissions from the production of construction materials.

Action in the infrastructure sector is urgent as infrastructure assets have a long life span. Countries experiencing rapid growth face a critical window of opportunity to develop a low-emissions stock of infrastructure, or risk becoming 'locked-in' to high-carbon growth during a period which is critical for the climate.

Adaptation

Climate change impacts will affect the infrastructure sector through two main channels. First, new climatic conditions will need to be taken into account at every stage of the project cycle for **baseline infrastructure**. Climate change will result in an overall increase in costs, as: some prospective sites become unviable; new facilities are constructed to be more resilient; operation, maintenance and insurance costs increase; and some infrastructure requires retrofitting to withstand climate change impacts (World Bank, 2010c). The task of adapting the infrastructure sector to climate change is complicated by a high degree of uncertainty around future impacts. But certain actions are clearly cost effective. These include changing design standards and submitting long-lived infrastructure to climate-robustness assessments. Most infrastructure currently being planned will be affected by climate change, so the mainstreaming of climate risk assessments into infrastructure planning is urgent to avoid negative outcomes ranging from sub-optimal investment to catastrophic failures.

Second, a range of **dedicated adaptation infrastructure** will be

required, including coastal zone protection to withstand sea level rise, riverine flood protection, and water supply and agricultural infrastructure for areas suffering drought and saline intrusion. Vulnerability to climate impacts is a function of three factors: *exposure* to risk, *sensitivity* to that risk, and *adaptive capacity* (IPCC, 2007b). Ideally, investment decisions would be made on the basis of a joined-up risk assessment of these three factors, but accurate information on all three is severely limited. The prevailing wisdom is to opt for investments that are robust under most climate scenarios until better information is available (World Bank, 2010d). These are often termed ‘no regrets’ or ‘low regrets’ options, and are typically investments that are priorities for development even without climate change.

Given that vulnerable people’s exposure to climate change impacts is a function not only of their exposure to risk, but also their socio-economic circumstances, it will be important to combine ‘hard’ approaches (i.e. investments in physical infrastructure) with interventions aimed at building capacity and resilient livelihoods.

Key Challenge 1: Finance

Sourcing the funding required to realise the changes described above is a challenge of daunting proportions. According to recent estimates, hundreds of billions of dollars annually are required for mitigation needs associated with the infrastructure sector in the developing world between now and 2030 (McKinsey and Company, 2009) and (very) approximately \$75 billion annually for adaptation needs in the infrastructure sector from 2010-2050 (World Bank, 2010c). Given the global distribution of responsibility for emissions, and the

current distribution of wealth, there is a powerful argument that the vast majority of this funding should be supplied through transfers from developed countries. The ethical case for such transfers is supported by pragmatic arguments that it is far beyond the capacity of most developing countries to supply funding on the scale required.

North-South financial transfers are currently occurring through two channels: bilateral and multilateral donor flows; and carbon market mechanisms such as the Clean Development Mechanism (CDM), which allows industrialised countries with emission-reduction targets to implement emission-reduction projects in developing countries in order to meet those targets. However, funding flows remain inadequate by a large margin. Delaying action will only increase the eventual cost of temperature stabilisation (Stern, 2006) (as well as resulting in increasingly severe impacts), so new and innovative strategies are urgently needed to increase the volume of funding flows.

Market mechanisms, and particularly the CDM, are widely expected to make an increasing contribution to North-South financial transfers for climate change mitigation in the coming decades. Such mechanisms will also contribute to optimising the global distribution of mitigation investment, as many of the most cost-effective abatement opportunities are in the global South. But many argue that CDM financial flows are not reaching some of the sectors and countries where they are most needed. At present, CDM finance is limited to narrow range of countries with relatively strong investment environments (generally the more

industrialised developing countries), and the Mechanism is dominated by energy projects and is raising little funding for the key infrastructure sectors of transport and the built environment. One proposed approach to reforming the CDM with particular relevance for the infrastructure sector is ‘sectoral CDM’ whereby emissions reductions would be rewarded across sectors, as opposed to the current scheme in which reductions are associated with a project. Proponents argue that this would improve the sectoral allocation of funding and create the right incentives, and the necessary scale of funding, for governments to achieve sector-wide transformations to low-carbon growth paths (Sterk & Wittneben, 2006).

Few would dispute that carbon markets have a vital role to play in mobilising North-South financial transfers for climate change, but there are many funding needs that they cannot meet. Donor funding provides a vital source of support in the poorest countries which have limited resources and struggle to attract private investment, and also facilitates activities such as capacity-building, technology transfer, and risk mitigation which play an essential ‘leveraging’ role in making the transition to a climate-friendly and resilient world, and have no obvious alternative source of finance. However, donor funding to date falls far short of the volume estimated to be required (discussed further in the analysis of funding flows below). Scaled-up funding is urgently required, while it will also be important to make the best use of the limited funds available by exploiting synergies with existing financial flows - including existing aid transfers - and to ensure that donor contributions are well

coordinated across sectors, countries and regions.

International financial transfers will need to be combined with national policies in developing countries to encourage climate-friendly and resilient domestic investment in order to mobilise change on the scale required. Appropriate national policies will differ between countries depending on their stage of economic development among other factors. Examples include pricing carbon, regulating for energy efficiency, and revised zone planning and building codes that take into account new climatic conditions.

Approaches to raising climate-related infrastructure finance differ depending on whether they are directed at mitigation or adaptation. There is greater scope to leverage private finance for mitigation than adaptation in the infrastructure sector, principally because most emission-producing infrastructure is privately owned, whereas a great deal of the infrastructure that needs to be climate-proofed is publicly owned. Further, there is limited scope for private investment in dedicated adaptation infrastructure as it does not create commercial revenue (World Bank, 2010c). This implies that the principal source of adaptation infrastructure funding is likely to be donor transfers and developing country government budgets (although private agents will also carry part of the burden as they invest in adapting their assets), while it is anticipated that the private sector will make a significant contribution to funding mitigation investment. However, raising private finance for infrastructure in the developing world has proved consistently challenging, especially for countries with weaker investment environments. Increased risk mitigation from public

sources (including donors) in the form of guarantees, grants and loans could help to encourage private green infrastructure investment in the developing world.

Key Challenge 2: Technology

Technological progress plays a crucial role in reducing carbon emissions from the infrastructure sector. While less critical for adaptation, protecting communities from the impacts of climate change will also require technological innovation.

Considering mitigation, many of the technologies required to reduce emissions and achieve low-carbon growth are similar across the globe, and it seems likely that richer countries will take a lead in developing these technologies. Technology transfer from the global North to the global South is therefore crucial to enable the shift to low-carbon economies within the timescale required. The active support of donors and international organisations will play a key role in efforts to achieve this, through initiatives such as international and regional organisations to promote technology transfer, international financial transfers, and possibly changes to international intellectual property laws.

However, international initiatives alone will not be enough to achieve technology transfer on the scale and within the timescale required, as many developing countries are limited in their capacity to absorb new technologies. Efforts to promote the dissemination of technologies will stand a far higher chance of success if they are combined with initiatives (on the part of donors and developing country governments) to enhance absorptive capacities (World Bank, 2010a). Key constraints include low

levels of technical expertise, weak legal frameworks to protect intellectual property rights, and the absence of institutions able to promote and coordinate technology transfer.

Some low-carbon technologies (such as low-cost, decentralised renewable energy for sub-Saharan Africa) and many adaptation technologies (such as small-scale irrigation) are specific to developing country contexts. For these technologies more localised development strategies will be required, such as regional innovation centres, and South-South technology transfer will play a more important role than North-South technology transfer. Again, donors could play an important role in supporting such initiatives through funding and technical assistance.

Key Challenge 3: Capacity

The scale and urgency of the climate change challenge demands an ambitious response, yet developing countries can only take actions that are consistent with their capacity level (Willems & Baumert, 2003). National governments' success in coping with climate change will depend to a large degree on their ability to develop coherent climate change policy frameworks that: integrate climate change objectives with national plans and budgetary frameworks; facilitate integrated climate change planning across sectors and scales; and support the mainstreaming of mitigation and adaptation objectives routinely into policy decisions across a broad spectrum.

This is difficult to achieve in many developing countries due to institutional weaknesses, poor access to information and modelling, low levels of human capacity, and inadequate financial resources.

Climate change policy development is uniquely challenging because the issue spans across multiple sectors and scales, and so requires extensive coordination between government agencies that normally work in silos. Building the capacity of developing country governments to formulate and implement climate change policy will therefore form an important part of programmes to support developing countries in meeting the challenge of climate change.

In the infrastructure sector, the challenges are exacerbated by existing capacity barriers in institutions responsible for infrastructure development. Capacity-building strategies will need to be based on an understanding of which agencies are the most appropriate to take a leading role in climate change infrastructure policy, and their existing capacity and institutional characteristics.

Support from high-income countries is critical in building capacity. Donors are well positioned to work through existing channels of development assistance to build capacity for integrating climate change into developmental decisions in the relevant institutions. However, the process of capacity-building is complex, context-dependent and requires a long time horizon. In the short-term, at least for countries with lower capacity, a combination of 'project approach' interventions relying on foreign technical and management expertise and more gradual interventions focused on building the requisite capacity in the partner country is likely to be required to meet needs within the timescale required. One proposed model for achieving this is "a step by step approach, whereby countries in each step assess their existing

capacities and select future actions that are consistent with the capacity level it can reasonably reach within a given time frame" (Willems & Baumert, 2003, p.5).

Maximising the developmental outcomes of mitigation in the infrastructure sector

The consequences of climate change are often seen as overwhelmingly negative for developing countries, but developmental opportunities are also created by international and national policies for mitigation and adaptation in the infrastructure sector. Taking advantage of these opportunities can help to counteract the negative economic and social impacts that result from new climatic conditions and offset the dampening effect on growth that many developing countries fear will result from emissions limitations.

Opportunities for developing countries arising from *international* efforts at mitigation include: access to new sources of finance, since many of the most cost effective mitigation opportunities are in the developing world; accelerated rates of technology transfer; and access to new international markets for green products. Harnessing these opportunities will require proactive policy development on the part of governments, a key element of which would be a coherent and clearly articulated national mitigation strategy. Such a strategy would position the country to attract international funding, and give business the confidence to make low-carbon investments in the knowledge that future policy development will be consistent with a positive return on their investment (Ellis et al., 2010).

Countries in the process of transition to a low-carbon economy will also experience a transition in the labour

market, which is projected to generate additional 'green' jobs in the infrastructure sector, particularly in renewable energy and the buildings sector. The buildings sector holds unique potential for pro-poor green job creation: firstly, because the construction sector is principally made up of small and medium enterprises (SMEs) that tend to employ a high proportion of unskilled workers and recycle much of their profits back into their communities; secondly, work to improve the energy efficiency of buildings will almost always be carried out on site, so much of the benefit will accrue locally. Proactive policy development on the part of governments will be required to harness the poverty-reduction opportunities associated with green jobs, including programmes to build the capacity of green workers (UNEP, ILO, OIE, ITUC, 2008a).

When taking decisions on how to invest international or national mitigation funding, developing country policymakers can take advantage of the many synergies that exist between national mitigation strategies and national development priorities. For example, in developing countries where a high proportion of the population still lack access to electricity, investment in decentralised forms of energy, such as solar or wind power could achieve both green growth and more inclusive growth (further examples are given in Annex A). Identifying and exploiting these synergies can support efforts to achieve long-term developmental goals and will also serve to enhance the relevance and popularity of mitigation projects. Climate change infrastructure investment decisions should ideally be informed by a thorough analysis of potential mitigation-adaptation-

development synergies, and their relationship with developmental paths, in order to generate the greatest economic, social and environmental value (Wilbanks & Sathaye, 2007). Donors may be able to assist by supporting the development of decision frameworks to guide this process.

Countries with smaller economies could better position themselves to profit from international funding flows associated with mitigation by forming economic alliances with neighbouring countries, and thus creating larger markets that are more attractive to entrepreneurs. Enhanced regional cooperation would also facilitate regional technology transfer and cross-border access to renewable power sources such as hydroelectric dams. Efforts to enhance regional cooperation would need to overcome political and institutional challenges. A starting point would be to build upon existing models of regional cooperation and existing regional ties.

Maximising the developmental outcomes of adaptation infrastructure investment

Donors will provide or leverage increasing volumes of funding for adaptation in the coming decades, much of which will be allocated to the infrastructure sector². Developmental outcomes will depend on how this funding is apportioned and managed. As discussed above, the most

vulnerable groups in society have lowest adaptive capacity, but hold least responsibility for the emissions that have caused climate change, so there is a strong case for maximising the developmental outcomes of adaptation-related infrastructure investment for these groups. A feature of such an approach would be to combine investment in physical infrastructure assets with programmes to build capacity to cope with impacts and improve the resilience of livelihoods within communities in the project vicinity.

Three tried and tested methods for generating pro-poor outcomes from infrastructure investments are: stakeholder engagement, incorporating explicit efforts to include the poorest and most vulnerable; community-led projects; and pro-poor employment creation.

Stakeholder engagement enhances developmental outcomes in many ways, but in the context of adaptation infrastructure investment, it would support the development of appropriate solutions, informed by stakeholder perceptions of risk, vulnerability and capacity, as well as raising awareness amongst stakeholders of the likely impacts of climate change.

Many adaptation infrastructure projects are well suited to small-scale, low or medium-technology community-driven schemes, for example irrigation, rainwater storage, small dams and flood defences, and maintenance and rehabilitation of drainage systems and gravel roads. Implementing these projects as community-driven schemes can generate employment within the community, create ownership amongst community members, empower the vulnerable, and increase social capital, which is a key element of adaptive capacity.

The developmental outcomes of adaptation-related infrastructure investment could also be enhanced through greater cooperation with neighbouring countries. Climatic phenomena do not respect borders so coping effectively with impacts such as water scarcity, flooding and sea level rise will require close cooperation between countries. Regional cooperation would also facilitate the pooling of information and resources for tasks including the generation of climate models, and capacity-building and vulnerability and risk-assessment exercises. Again, regional cooperation holds particular significance for poorer countries with smaller economies.

Analysis of climate-related infrastructure investment needs, donor and CDM infrastructure funding flows, and low-carbon growth strategies in nine countries

Estimates of funding required by infrastructure sector and region

According to estimates in the report "Pathways to a Low Carbon Economy: Version 2 of the Global Greenhouse Gas Cost Abatement Curve" (2009): 67% of global abatement potential³ is in the developing world and, in order to achieve the optimum global abatement curve:

- the infrastructure sector requiring greatest investment is the buildings sector by a significant margin (\$155 bn and \$248 bn

² According to estimates in the World Bank report "The Cost to Developing Countries of Adapting to Climate Change: New Methods and Estimates" (2010) approximately 75% of adaptation investment in the developing world will be required in the infrastructure sector as defined in this report.

³ Abatement potential is defined as the maximum potential of all technical GHG abatement measures (i.e. without a material impact on the lifestyle of consumers) below €60 (\$75) per tonne, if each opportunity were pursued aggressively from 2010. McKinsey and Company estimate that this would stabilise global warming below 2°C.

annually globally⁴ in 2015 and 2030 respectively), although, due to the resulting cost savings, the net cost to society of achieving optimum abatement in the buildings sector is negative in the long term;

- the energy sector comes in second in terms of capital expenditure (\$65 bn and \$185 bn annually in 2015 and 2030 respectively), but the operational cost savings are far lower than for the buildings sector, so the long term cost to society is high;
- the developing region requiring greatest investment by far is Asia.

According to estimates in the World Bank report “The Cost to Developing Countries of Adapting to Climate Change: New Methods and Estimates” (2010):

- \$74.6 billion annually on average will be required in developing countries for adaptation investment in the infrastructure sector between 2010-2050;
- the greatest anticipated cost is for constructing, operating and maintaining baseline levels of infrastructure services under new conditions (39%), followed by coastal zone protection (34%), water supply and riverine flood protection (18%), and agricultural infrastructure (8%);
- total infrastructure adaptation costs are greatest in Asia by a significant margin, but sub-Saharan Africa will shoulder a greater burden in proportional terms: 0.6% of GDP compared to 0.1% in Asia.

Analysis of donor funding flows

Infrastructure funding flows were analysed for approved projects from

⁴ Disaggregated figures for the developing world are not available.

seven Climate Funds^{5,6}. From these funds, \$3.2 billion of direct donor funding had been raised for mitigation infrastructure up to September 2010, and \$100 million (just 3% of the total) for adaptation infrastructure. Considering full project cost including co-financing leveraged, \$23 billion has been raised for mitigation and \$590 million (2%) for adaptation.

While it is difficult to make statements about the appropriate balance between mitigation and adaptation without country-level detailed assessments of needs, these figures suggest that donor infrastructure funding flows may currently be excessively skewed towards mitigation. Alternative sources of finance are not readily available for adaptation (unlike mitigation where carbon markets and the domestic private sector are likely to provide a significant proportion of funding), so funding not provided by donors is likely to come principally from developing country governments’ budgets. The analysis suggests that donor funding flows for adaptation infrastructure investment are inadequate by a significant margin⁷. Scaled up donor

⁵ Bilateral and multilateral donor funds established explicitly to fund climate change activities. They do not encompass the full range of donor funding available.

⁶ See Annex B for a full methodology for the climate funding data analysis.

⁷ It should be noted that this is an incomplete analysis of financial flows, which include additional bilateral and multilateral donor funding flows and private funding. However, given the gulf between funding available from the Climate Funds - currently \$590 million in total to date – and the World Bank estimate that \$74.6 billion annually will be required on average from 2010 – 2050, it seems reasonable to conclude

funding, combined with new and innovative funding strategies are urgently needed to meet adaptation infrastructure funding needs.

Mitigation funding from the Climate Funds

Energy projects dominate the Climate Funds mitigation project costs, with energy production and efficiency absorbing 58% of total funds. The buildings sector is receiving just 14% of project funding provided or leveraged by the Climate Funds. It seems probable that this is lower than the optimum given the outcomes of the McKinsey and Company (2009) analysis, although it is difficult to come to any firm conclusions without an understanding of the sectoral distribution of private investment.

Many of the projects contribute to national developmental objectives as well as mitigation. For example, 95% of transport project costs are allocated to urban transportation management which will contribute to increased mobility and reduced air pollution as well as emissions reductions. This suggests that (unsurprisingly) developing country policymakers are seeking projects with developmental synergies.

Adaptation funding from the Climate Funds and NAPAs

Adaptation infrastructure funding requested under the National Adaptation Programmes of Action (NAPAs)⁸ is dominated by agricultural water supply, with 75% of the total⁹. In contrast, approved

that adaptation-related infrastructure funding flows are currently inadequate.

⁸ The NAPAs are a special programme to support adaptive capacity in Least Developed Countries, funded by the GEF’s Least Developed Countries Fund.

⁹ For the Climate Funds, only funding for projects that have been *approved* is

funding under the Climate Funds is dominated by coastal protection, with 59%. Funding from the NAPAs programme is open to least developed countries (LDCs) only, so this is in part a reflection of the agrarian economies of most LDCs. The focus on agricultural water supply reflects policymakers' prevailing concerns and understandable desire to use Climate Funds to meet the immediate needs of their citizens, where the two objectives coincide.

The NAPAs sectoral balance is in sharp contrast to the World Bank's estimates (2010c), which predict that just 5% of adaptation infrastructure funding will be required for irrigation infrastructure¹⁰, and 34% for coastal zone protection. This is at least partly attributable to the NAPAs' specific focus on meeting the "urgent and immediate needs" of LDCs. However, with only 2% of Climate Funds infrastructure project funding going to adaptation, the analysis raises concerns over how this more strategic, long-term adaptation infrastructure will be financed. The contrast in the sectoral balance between the NAPAs and the World Bank's predictions, and the relatively low-level of funding applied for compared to that required illustrate the urgent need to build policymakers' understanding of the future impacts of climate change, their ability to develop projects, and their access to high-quality predictive models.

included in the analysis. Few NAPA projects have been approved to date, so the analysis has been carried out of all infrastructure projects for which funding has been requested under the NAPAs.

¹⁰ Although, at \$3.4 billion annually, this is still considerably more than that applied for through the NAPAs.

The Clean Development Mechanism

CDM projects are dominated by energy when considering either project numbers or Certified Emission Reductions (CERs). Energy production, energy efficiency and 'energy-other' make up 79% by project number and 58% by CERs. The resources available for transportation projects under the CDM are minimal, making up just 1% of the portfolio by both project numbers and CERs. The proportion of projects or CERs for energy efficiency in buildings is lower than the McKinsey and company analysis suggests is optimal: less than 14% by project numbers or 11% by CERs. These findings illustrate the case for reforming the CDM in order to encourage the inclusion of transportation and buildings projects.

Case studies of low-carbon growth strategies in nine countries

The following are the key findings from case studies of low-carbon growth strategies in Bangladesh, Brazil, China, Ethiopia, Guyana, Mexico, Nigeria, Malawi and Rwanda:

- Provisions related to infrastructure development, particularly energy and transportation, form the backbone of many countries' climate change plans. Low-carbon growth strategies in the infrastructure sector vary considerably between country income brackets.
- Proactive plans to harness opportunities from national mitigation strategies are more evident in middle-income countries (MICs) than low-income countries (LICs).
- In the LIC documents reviewed, there is little discussion of the financial incentives or regulation with which their planned policies

will be implemented, reflecting the early stage they are at in developing low carbon policies.

- The low carbon growth strategy documents show that finance is fundamental to implementation and is linked to all proposals made under countries' low carbon development plans, yet it remains scarce, particularly for LICs.
- Consultation of the private sector appears to have been limited in most countries.
- Overall, in MICs the biggest issue seems to be a lack of coordination between implementing bodies, unaligned policies and weak enforcement at the local level. In LICs, capacity represents the most significant barrier to implementation, including lack of training and expertise in climate change issues and weak enforcement and oversight.
- Therefore, key requirements for developing countries to successfully implement their plans include the need to build capacity, and enhance coordination between ministries, as well as wider steps to provide adequate public finance and improve the investment climate and market mechanisms in order to stimulate private financing.

Recommendations and areas for further study

The recommendations given are directed towards donors, but would also be of interest to developing country policymakers, researchers and infrastructure professionals.

Recommendations for donors

Support programmes to raise awareness amongst developing country policymakers, the private sector and civil society of the urgency of taking action in the infrastructure sector in order to avoid becoming 'locked-in' to high-

emissions pathways and developing infrastructure stocks that are not suited to new climatic conditions.

Support partner country governments in developing and implementing climate change policy frameworks:

- Support the development of decision making frameworks to help countries identify and prioritise mitigation and adaptation-related infrastructure investment needs, and balance these needs with developmental priorities.
- Raise awareness amongst policymakers in the developing world of the potential synergies between mitigation, adaptation and development, and support the development of tools to facilitate the identification and capture of these synergies.
- Support partner country governments in developing strategies to overcome the barriers to rapid, cost-saving emissions reductions in the buildings sector as a priority. These would include updated and better-enforced building codes, financial incentives, and education and awareness-raising.
- Assist partner country governments in preparing the infrastructure sector for climate impacts that are still uncertain. Possible approaches include: support governments in implementing cost-effective measures to climate-proof future baseline infrastructure, such as changes to building codes and climate-risk assessments at planning stage; build the capacity of infrastructure decision-makers to identify options for dedicated adaptation infrastructure that are 'no-regrets' or 'low-regrets', i.e.

that are robust under most climate scenarios.

- Lead by example by adopting climate risk assessments as standard in project planning for donor supported infrastructure projects and disseminate the tools and knowledge generated¹¹.
- Support developing country partner governments in engaging in broad-based consultation during the development of low-carbon growth strategies, including consultation with civil society and the private sector.

Support programmes to build capacity in partner country governments, the private sector and civil society:

- Work through existing channels of development assistance to build capacity for integrating climate change into developmental decisions in the relevant government institutions.
- Develop capacity-building strategies for climate change in the infrastructure sector in partnership with partner country governments, with input from the private sector and professional institutions, and on the basis of an understanding of the existing capacity and institutional characteristics of the agencies most appropriate to take a leading role in climate-related infrastructure policy development.
- Build the capacity of developing country policymakers (particularly in lower-income countries) to develop mitigation and adaptation-related infrastructure project proposals for international funding.
- Support programmes to build the capacity of 'green workers' who could benefit from the jobs

created by transition to a low-carbon economy in the labour market.

Scale-up, balance and coordinate funding flows for climate-related infrastructure:

- Scale-up donor funding flows for climate-related infrastructure investment in order to enable developing countries to achieve mitigation and adaptation goals within the timescale required.
- Scaling up funding for adaptation infrastructure investment appears to be particularly urgent as this study has found a very high proportion of donor funding for infrastructure flowing to mitigation, and there is little scope to raise adaptation funding from private sources.
- In order to make the best use of limited donor funds, exploit synergies with existing financial flows - including existing aid transfers - and improve the coordination of donor contributions across sectors, countries and regions.

Maximise the pro-poor outcomes of donor-supported adaptation infrastructure projects:

- Combine investment in physical infrastructure with programmes to enhance adaptive capacity and the resilience of livelihoods.
- Adopt community-led approaches to adaptation infrastructure projects where possible, with the aim of generating benefits including employment generation, ownership, empowerment, and enhanced social capital.
- Develop a stakeholder engagement plan that incorporates explicit strategies to include the poorest and most vulnerable.

¹¹ Some donors are already making progress in this area; see section 3.2.

Support efforts to mobilise private sector support for climate-related infrastructure investment:

- Encourage private sector investment in green infrastructure in countries with challenging investment climates by providing risk mitigation in the form of guarantees, grants and loans.
- Support developing country partners in creating incentives for private investors to adapt new physical assets to climate change impacts.

Support reforms to the CDM:

- Support reforms to the CDM which would result in the allocation of a greater proportion of CDM financing to the key infrastructure sectors of transport and the built environment, and to a wider range of country income groups. One possible approach would be funding research to model the outcomes of various possible reforms, thus creating a stronger evidence base for pro-reform positions in international negotiations.

Support scaled-up technology transfer and innovation at international, regional and national level:

- Combine international initiatives to promote technology acquisition with programmes to build absorptive capacity in developing countries. Such programmes would support any or all of: the development of technical expertise, strengthening of legal frameworks to protect intellectual property rights, the creation of institutions able to promote and coordinate technology transfer.
- In addition, support national and/or regional programmes to

develop technologies required specifically for developing country contexts, such as low-cost decentralised renewable energy for mitigation, and small-scale irrigation for adaptation.

Areas for Further Study (for donors or others)

Compile evidence in key areas and support the development of policy accordingly:

- Compile evidence of the developmental benefits of switching from high-emissions development to low-emissions pathways (particularly for lower-income countries), and the policy frameworks that optimise these developmental outcomes.
- Compile evidence on the potential for pro-poor green job creation in the buildings sector, and provide support in developing policy to capture these benefits.
- Research the costs associated with regulating for reduced emissions and climate robustness in the infrastructure sector. Use this to support the development of mechanisms to compensate developing country governments and private sector actors for these costs, thus providing incentives to implement and enforce climate-related regulations.
- Further research is required into the implications of the high proportion of construction activities that take place in the informal sector in developing countries for attempts to reduce emissions and prevent maladaptation through regulation, and potential approaches to reducing this barrier.
- The analysis of funding flows in this report raises several concerns and demonstrates the need for a

more extensive analysis of climate-related infrastructure funding flows by sector, and by mitigation and adaptation, including – as far as is possible – donor funding flows beyond the Climate Funds and private sector flows. The analysis could be used to understand whether the very high proportion of funding flowing to mitigation found in this study still stands when a wider range of funding sources are taken into account, as well as providing valuable evidence on the allocation of infrastructure funding flows between sectors and countries. Of particular importance is further investigation into whether the buildings sector is receiving the support needed to realise the substantial and cost-effective mitigation opportunities it presents.

- Further research is required into the potential benefits of, and obstacles to, regional cooperation for adaptation and mitigation programmes in the infrastructure sector, possibly with a focus on sub-Saharan Africa. One focus area would be existing regional groupings and models of cooperation, and the extent to which these can be built upon for climate change programmes.

Areas in which research has already been carried out, but additional evidence and case studies would be valuable:

- The role of public-private partnerships in promoting green investment in, and technology transfer to, the developing world.
- Procurement strategies to encourage low-carbon, climate resilient infrastructure development.

1. Introduction

Climate change is one of the most significant threats to development during the 21st Century and beyond. Infrastructure policy and the engineering industry play a pivotal role in the global response, both in efforts to reduce greenhouse gas emissions (mitigation) and in developing infrastructure that responds to climatic changes (adaptation).

Over half of GHG emissions are associated with the infrastructure sector and the construction industry (World Bank, 2010a), so reducing infrastructure-related emissions plays an essential part in efforts to prevent dangerous levels of global warming. Adapting baseline infrastructure to new climatic conditions and building new, dedicated adaptation infrastructure to protect human settlements from climate impacts will play a central role in successful adaptation. One recent study predicts that approximately 75% of the adaptation investment needed in the developing world will be required in the infrastructure sector (World Bank, 2010c).

Infrastructure: The definition of infrastructure used here is broad and encompasses the OECD definition of economic infrastructure to include transport, energy, information and communication technology, irrigation, drinking water and sanitation (OECD/DAC, 2006) as well as the UK Institution of Civil Engineer's definition of civil engineering infrastructure which covers bridges, roads, canals, dams, tall buildings and other large structures (ICE, 2010).

The challenge of making the transition to a low-carbon, climate

resilient infrastructure sector is daunting in its scale and urgency. Action is particularly urgent in the sector due to the long life span of infrastructure investments (generally 60-100 years) and the rapid rate of accumulation of infrastructure assets in many parts of the developing world. This set of circumstances creates a critical window of opportunity for countries to integrate adaptation and mitigation considerations into their investment decisions, or risk becoming 'locked-in' to high carbon growth paths, and developing infrastructure stocks that are not resilient to new climatic conditions. There is a very real risk that, in the coming decades, such an outcome would dampen the growth and poverty reduction effects normally associated with infrastructure development, as emissions limitations are applied to more industrialised developing countries, thus dampening their growth rates, and new climatic conditions become manifest.

The challenge of developing climate-friendly and resilient infrastructure is amplified by existing challenges in the infrastructure sector in developing countries. Two of the greatest barriers are limited access to finance, and limited capacity for policy development and strategic planning within governments. Governments already struggling to realise infrastructure investment commensurate with their growth and poverty reduction goals must now add an additional layer of complexity to their policy formation and investment decisions and search for additional finance to meet new infrastructure investment needs.

The outcomes of climate change are often seen as overwhelmingly

negative for the developing world, but opportunities are also generated by international and national policies for mitigation and adaptation. In the case of mitigation, these include: access to new sources of international finance and international markets; technology transfer; the creation of additional 'green' jobs, particularly in the renewable energy and buildings sectors; and development win-wins created by synergies between national mitigation strategies and development priorities. In the case of adaptation, opportunities are associated with the increasing volumes of funding that donors will provide or leverage in the coming decades, although it is of course questionable whether this funding will compensate for the negative impacts associated with climate change.

Given the urgency and scale of the challenge, and the complex and evolving risks and opportunities described above, developing an improved understanding of the relationship between climate change, infrastructure and development could not be more important at the present time.

Research Objectives and Report Structure

The aim of this report is to provide an overview of the challenges and opportunities at the nexus of climate change, infrastructure and development. This is approached through the objectives listed below:

1. Describe the transformation required in the infrastructure sector to promote low-carbon growth and climate-resilient development.
2. Identify the key challenges to achieving this transition within the

required timeframe in the developing world, and the strategies that have been developed to date to meet these challenges. Take preliminary steps towards identifying the further action likely to be required.

3. Explore potential developmental opportunities associated with international and national efforts at mitigation and discuss, in general terms, how they can be realised.
4. Identify approaches to maximising the developmental outcomes of adaptation investment in the infrastructure sector.
5. Analyse climate-related infrastructure funding flows from donors and the Clean Development Mechanism (CDM), compare these with estimated needs, and draw preliminary conclusions from the trends observed.
6. Develop an improved understanding of the reality of climate change policy development in the infrastructure sector by studying the infrastructure-related low-carbon growth strategies of nine countries.
7. Draw conclusions and make recommendations based on the above, and identify priority areas for further study.

The objectives of the report are broad, the topic is complex and this study makes no claim to completeness. Rather it aims to provide an introduction to the theme and a base for further research. The report summarises and synthesises existing material and data; it does not include any primary research.

A summary of key points is provided at the end of each main section.

The report is structured as follows:

Section 2 provides a brief introduction to climate change (2.1) and the relationship between climate change and development (2.2). Section 3 discusses how climate change will affect the infrastructure sector in the developing world, starting with mitigation (3.1), moving on to adaptation (3.2) and finally discussing challenges associated with finding a balance between mitigation and adaptation in the infrastructure sector (3.3).

Sections 4, 5 and 6 discuss the key challenges to achieving climate compatible development in the infrastructure sector. Section 4 explores the challenge of raising the massive volume of funding required, starting with a discussion of sources of finance from the global North (4.1), going on to discuss strategies for raising domestic finance (4.2) and finishing with a discussion of the likely distribution of finance between the public and private sectors to meet infrastructure investment needs (4.3). Section 5 discusses challenges associated with technology development (5.1) and technology transfer (5.2). Section 6 explores capacity barriers to meeting the challenge of climate change within national governments (6.1), and the role of high income countries in supporting capacity building (6.2).

Section 7 explores developmental opportunities associated with mitigation in the infrastructure sector. It starts with an overview of opportunities for developing countries arising from international mitigation strategies (7.1), goes on to explore the potential for the creation of green employment (7.2), discusses development win-wins created by synergies between national mitigation strategies and

development priorities (7.3) and finishes with a description of the advantages of regional cooperation for mitigation in the infrastructure sector (7.4).

Section 8 explores how the developmental outcomes of adaptation infrastructure investment can be maximised. Section 8.1 looks at the synergistic relationship between adaptation and development. Sections 8.2, 8.3 and 8.4 go on to outline some of the most important enablers of pro-poor infrastructure, with specific reference to adaptation infrastructure investment, these being stakeholder engagement, community-driven projects and employment creation. Finally, section 8.5 discusses opportunities associated with regional cooperation.

Section 9 aims to provide an improved understanding of how - and to what extent - the finance and policy development challenges discussed in previous sections are being met. Section 9.1 provides estimates of funding required for climate-related infrastructure investment by sector and region (sourced from reports by McKinsey and Company (2009) and the World Bank (2010c)). Section 9.2 provides an analysis of climate change infrastructure investment flows from donor Climate Funds, the NAPAs and the CDM, compares the outcomes to the estimates in section 9.1 and draws some preliminary conclusions. Section 9.3 summarises the main points from case studies of low-carbon growth strategies in nine countries.

Conclusions are drawn, recommendations made, and areas for further research identified in section 10.

The objectives of this project are broad, and the target audience is similarly broad. The report will be of use to anyone wishing to gain a basic understanding of this complex

and pressing topic, including policy makers, donors, industry professionals and civil society groups.

2. Climate Change and Development

This section provides a brief overview of current views on climate change and the relationship between climate change and development. Section 2.1 provides information on predicted temperature increases, emissions reductions targets, and projected impacts and the timescales and costs associated with them. Definitions of adaptation and mitigation and a discussion of carbon pricing are then provided in Boxes 1 and 2 respectively. Section 2.2 explores the relationship between climate change and development, covering the impact climate change is likely to have on development, the differing perspectives of countries at different stages of development and, finally, how the developmental pathways adopted by countries affect their future capacity to cope with both climate change impacts and constraints on greenhouse gas (GHG) emissions.

2.1. Climate change

That the earth's climate is warming is now seen as 'unequivocal' (IPCC, 2007a). Fourteen of the last fifteen years have been the warmest since global records began in 1850 (Met Office, 2010) and the impacts are manifest in the retreat of the Greenland and Antarctic ice sheets and increased precipitation and extreme weather events (IPCC, 2007a). That climate change is caused by human activity is also widely accepted. Post-industrial global atmospheric concentration of greenhouse gases that trap solar energy inside the earth's atmosphere currently far exceed the natural range over the past 650,000 years. Atmospheric concentrations of carbon dioxide, the most important GHG, were 36% higher in

2005 than pre-industrial averages, and carbon emissions have grown by approximately 80% between 1970 and 2004 (IPCC, 2007b). The primary source of carbon dioxide is fossil fuel use, although land use change also contributes.

Using a range of models and a variety of GHG emissions reductions scenarios, the Intergovernmental Panel on Climate Change (IPCC) has predicted an average global increase in temperature of between 1.8°C - 4°C by the end of the 21st Century compared to the end of the 20th Century (IPCC, 2007a). The wide range of possible temperature increase is a result of the uncertainty surrounding the point at which GHG emissions will be stabilised in terms of concentration and time, and the fact that the impact of feedback effects - such as reduced carbon uptake capacity of the earth and sea at higher temperatures - cannot be accurately predicted.

There is broad scientific consensus that global agreements should aim to limit warming to 2°C above 1990 temperatures to avoid 'dangerous anthropogenic interference with the climate system' (UNFCCC, 2009). Dangerous effects above 2°C include water stress and decreasing food productivity at low latitudes, greater disease burdens, 20-30% of existing species at high risk of extinction, and progressively greater risk that the terrestrial biosphere will become a net carbon source, locking the earth into a high emissions cycle that would be difficult to reverse. For the world to have a 50% chance of keeping within the 2°C ceiling, global emissions of greenhouse gases need to peak by 2020 at the latest, be cut by at least 50% of their 1990 levels by 2050, and continue to decline

thereafter (EC, 2010). It now seems highly unlikely that the 2°C limit will be met (UNFCCC, UNDP, 2009). Rapid and decisive action will be necessary to prevent irreversible damage to the earth's living systems. The key economic tool in reducing emissions is pricing carbon, discussed in Box 2.

Even if GHG emissions were immediately stabilised at their current levels, warming and sea level rise would continue far into the future, due to the timescales associated with climatic processes and feedback (IPCC, 2007a). If CO₂ emissions are stabilised within the next 100 years, the concentration of CO₂ in the atmosphere is likely to stabilise within 100-300 years, temperature within 'a few centuries', sea level rise due to thermal expansion within 'centuries to millennia' and sea level rise due to ice melting within several millennia (World Bank, 2010)¹². The implication is that some degree of global warming is now inevitable, and significant warming is likely to occur within this century.

Figure 1 illustrates the impacts that are likely to be experienced at different levels of warming.

¹² The IPCC predicts sea level rise this century to be in the region of 0.17m, but unmitigated climate change would eventually lead to a catastrophic rise of up to 7m.

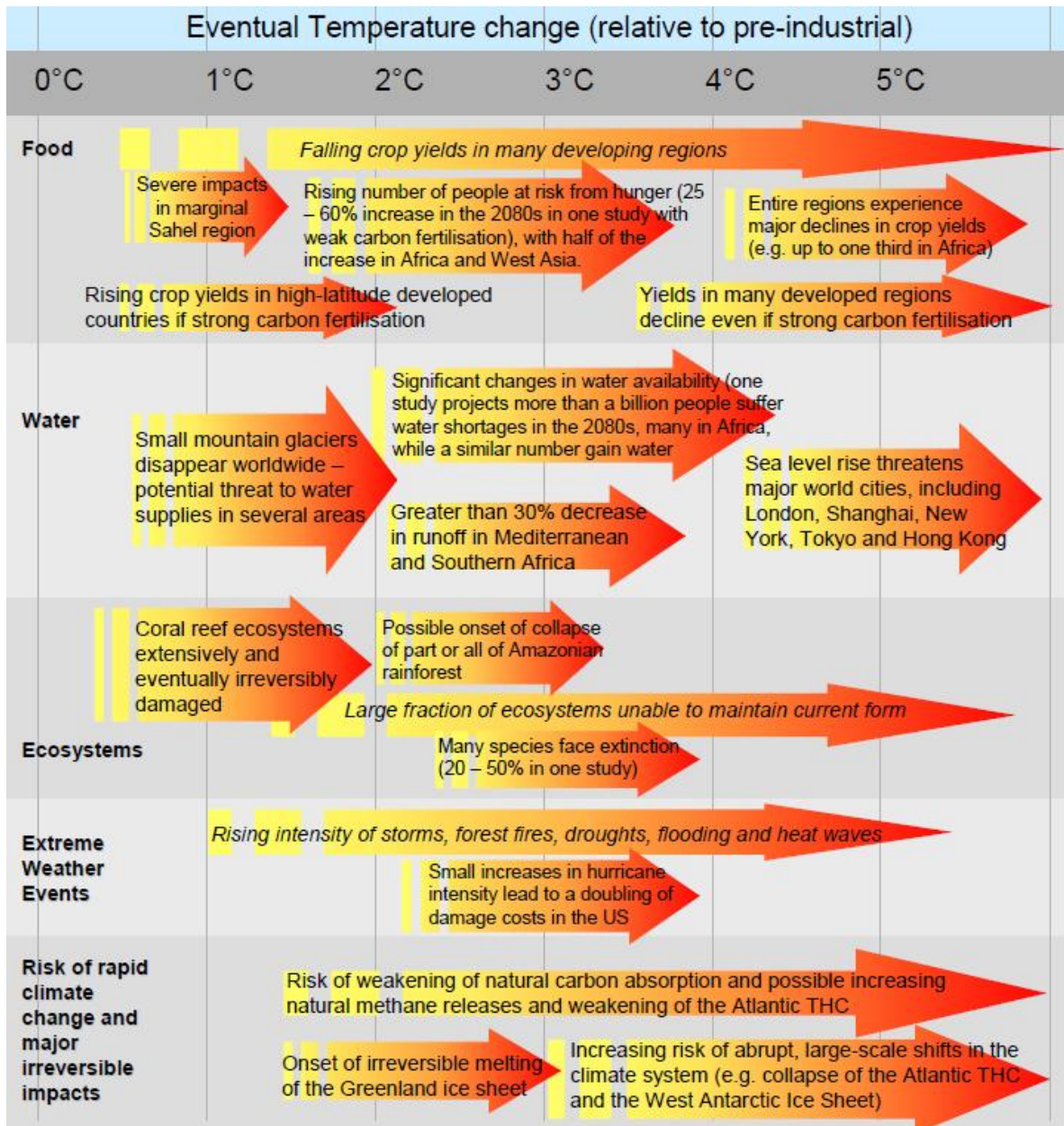


Figure 1: Climate change impacts at different levels of warming

Source: Stern (2006)

Immediate action is economically rational, as well as being necessary to prevent dangerous warming. The respected 2006 Stern Report finds that the costs of delaying action far outweigh the costs of immediate action. While Stern estimates the cost of stabilising emissions if immediate action is taken at around 1% of global GDP, the eventual costs of a 'business as usual' approach are estimated at 5-7% of global GDP in purely economic terms, 11-14% if 'non-market' costs to the environment and human health are

taken into account and 20% if a weighting is included to account for the unequal burden that will fall on poorer regions of the world (Stern, 2006).

Responses to climate change are classified as *mitigation* or *adaptation*. Definitions of these terms are given in Box 1, followed by a discussion of the differing policy responses they require.

Box 1. Mitigation and Adaptation

Mitigation

Technological change and substitution that reduce resource inputs and emissions per unit of output. Although several social, economic and technological policies would produce an emission reduction, with respect to Climate Change, mitigation means implementing policies to reduce greenhouse gas emissions and enhance sinks.

Adaptation

Initiatives and measures to reduce the vulnerability of natural and human systems against actual or expected climate change effects... Examples are raising river or coastal dikes, the

substitution of more temperature-shock resistant plants for sensitive ones, etc. (IPCC, 2007b)

Mitigation and adaptation require fundamentally different policy responses. Mitigation is a 'global public good', meaning that any one country engaging in efforts to reduce GHG emissions is generating global benefits, while the benefits of adaptation are limited to the country or region in which they are implemented. Global public goods create a collective action problem, whereby each nation has incentives to let other nations shoulder the economic burden of mitigation, while they 'free-ride', gaining the

benefits but not making the sacrifices. For this reason, global institutions and agreements with rules and enforcement mechanisms are necessary to leverage mitigation activities. Since the benefits of adaptation are localised, adaptation actions could, in theory, be implemented on a local basis. Because developing countries are least responsible for historic emissions, but are likely to suffer the greatest impacts, adaptation has been recognised (at least to some degree) as a global responsibility, and adaptation financing is an important issue in global negotiations.

Box 2. Pricing Carbon

Creating a carbon price is crucial to global efforts to reduce emissions. A carbon price which properly reflects the costs associated with carbon pollution will incentivise a change in behaviour through market forces which will reduce carbon emissions (to a degree dependent on the price), in line with the 'polluter pays' principle. An international carbon price could be created by capping the total global emissions of carbon at a certain level through an international agreement, and then allocating those emissions 'allowances' across countries. In the absence of such an agreement, the effective price of carbon can still be increased in a national or regional setting by imposing policy measures which increase the costs of carbon emissions. This can be achieved in a variety of ways, including through taxation or regulation. Emissions

trading and taxing carbon represent two important ways to establish a carbon price. *Emissions Trading Schemes* create a carbon price by capping emissions at a certain level and issuing emissions permits to companies, which can then be traded. By far the largest scheme is currently the EU Emissions Trading Scheme (EU ETS), although others exist and several more are planned. Trade in permits facilitates the efficient allocation of abatement opportunities, but the carbon price can be unstable. This instability has a negative impact on incentives to reduce emissions and invest in green innovation.

For the developing world, by far the most important carbon market mechanism currently in existence is the *Clean Development Mechanism (CDM)*. The CDM - defined within the Kyoto

Protocol¹³ - allows industrialised countries with emission-reduction targets to implement emission-reduction projects in developing countries. These projects earn saleable Certified Emission Reduction (CER) credits which count towards meeting Kyoto targets. The CDM is designed to stimulate sustainable development, as well as the efficient global distribution of emissions reductions, since abatement costs are lower in the developing world (UNFCCC, 2010c).

Carbon taxation imposes a stable blanket cost, and it is much harder to circumvent or manipulate than a trading scheme. However, it is politically difficult to impose. Carbon taxation is not currently widespread, but is likely to be needed in addition to trading schemes in future to prevent dangerous levels of warming.

¹³ The Kyoto Protocol is an international agreement linked to the United Nations Convention on Climate Change (UNFCCC). It sets binding targets for 37 industrialised countries and the EU to reduce greenhouse gas emissions, amounting to a 5% reduction from 1990 levels for the period 2008-2012 (UNFCCC, 2010a). Negotiations on the post-2012 climate regime are ongoing. There is broad consensus that if dangerous climate change is to be avoided post 2012, industrialised countries will need to accept considerably more stringent limits, while larger middle-income emitters will also need to accept binding emissions reductions targets.

2.2. *The relationship between climate change and development*

The relationship between climate change and development is complex and multi-faceted; climate change has far-reaching implications for development, but the developmental paths that countries adopt are also critical in deciding their capacity to reduce emissions and adapt to new climatic conditions. This section summarises the impacts that climate change is likely to have on development, starting with adaptation and moving on to mitigation, goes on to discuss the differing perspectives of countries at different stages of development, and finally considers the impact of developmental paths on climate change outcomes.

2.2.1. *The impact of climate change on development*

Developing countries bear little historic responsibility for the emissions that are causing climate change¹⁴, but they are likely to suffer the most severe consequences for three reasons. Firstly, the lower latitudes where most of the developing countries are located will suffer more from the negative effects of rising temperatures, including decreased crop

¹⁴ Today's high-income countries have generated about 80% of past fossil-fuel based emissions, despite having only 15% of the global population (UN-DESA, 2009d). Middle-income countries have recently overtaken high-income countries in overall emissions (principally due to a few high emitters, including China and India), but emissions per capita remain far higher in the West. Fifteen tons of CO₂ are emitted per head on average in the developed world, compared to five in middle-income countries and two in low income countries (World Bank, 2010a).

productivity, higher incidences of flooding and drought and greater disease burdens. Secondly, a higher proportion of the income of developing nations derives from climate sensitive sectors such as agriculture, fishing and tourism. Finally, developing countries have lower 'adaptive capacity' – their weaker institutions, lower human and financial capital, and constrained access to technology and credit render them less able to adapt (Burton et al, 2006). It has been estimated that for every 1°C rise in temperature, annual average growth in poor countries could drop by 2-3 percentage points, while advanced countries are likely to suffer far less severe economic impacts (UN-DESA, 2009f). Nicholas Stern has used the term "double inequity" to describe the injustice associated with developing countries suffering the greatest impacts from global warming, while carrying little responsibility for causing the problem.

Africa consistently emerges as the most vulnerable region to climate change, mainly because of its low adaptive capacity and its reliance on environmental capital for sources of livelihood (Reddy & Assenga, 2009, quoted in Chuku, 2010). Many developing countries, particularly least developed countries (LDCs) and small island developing states (SIDSs), simply will not be able to bear the cost of protecting their populations from the impacts of climate change. Within developing countries it is those individuals in the lowest income brackets, or who experience heightened vulnerability for other reasons, that are most vulnerable to the impacts of climate change. These groups have the least capacity to manage physical and financial risks, and to make long-term adaptation decisions, and are

Emissions: An unbalanced picture

The emissions reductions that could be achieved by switching all SUVs in the USA to cars with EU fuel economy standards is just slightly less than the emissions that would be created by providing electricity to 1.6 billion people across the developing world currently without access to electricity (World Bank, 2010a: 323)

most dependent on climate-sensitive sectors such as agriculture for their livelihoods (World Bank, 2010a). It is also these groups who have contributed the very least to global GHG emissions.

Added to risks associated with climate change impacts is the risk that the task of reducing global GHG emissions will compromise developing nations' opportunities for economic growth. GHG emissions from middle and low-income countries now make up 62% of the global total (World Bank, 2010a), and will continue to grow rapidly if they remain on their current trajectory¹⁵. Historically, economic growth has gone hand-in-hand with increased GHG emissions resulting from increased economic activity, and particularly greater energy consumption per capita. But, as the previous section makes clear, continued high-emissions growth is incompatible with sustainable development.

There is broad consensus that the incentives to make the transition to

¹⁵ For example, if all the coal-fired power plants proposed around the world over the next 25 years (most of which are in the developing world) are constructed, their lifetime CO₂ emissions would equal those of all coal-burning activities since the beginning of the industrial era (World Bank, 2010a).

low-carbon growth can only be created by pricing carbon, and eventually by pricing carbon globally¹⁶. But this raises questions over whether pricing carbon in developing countries would slow economic growth rates and thus compromise their developmental agendas. Developing countries rightfully argue that this would be profoundly unjust given the global distribution of responsibility for emissions to date, and the global distribution of wealth at this point in history.

2.2.2. Differing perspectives and priorities of countries at different stages of development

The relative importance governments assign to adaptation and mitigation will depend on the climate impacts their countries are projected to suffer and their adaptive capacity, their stage of economic development and emissions profile, and other factors related to their developmental path. In order to illustrate the range of possible perspectives, the following paragraphs first discuss the situation faced by a relatively industrialised, high-emitting, fast growing country, followed by a discussion of a country at the opposite extreme; a low-income (or least developed) country with a largely agrarian economy, relatively growth rates, and very low emissions. Most countries fall between these two extremes, while others face challenges particular to

their economies, for example the potential threat of reduced prices for fossil fuel exports (Ellis et al, 2010).

Higher-emitting rapidly growing countries are under increasing pressure to adopt emissions limitations in the near future as part of international negotiations under the United National Framework Convention on Climate Change (UNFCCC). There are questions over whether limiting emissions in countries still at relatively early stages of development is just, although the rationale behind doing so is clear. China has recently taken over from the USA as the world's largest emitter, and India is in third place, so action to reduce emissions in these (and similar) economies is urgent.

In order to experience rapid growth in the coming decades, these countries will need to 'leapfrog' the dirty production methods adopted by rich countries, and develop low-emissions technologies and patterns of growth that enable low-carbon growth paths (Ellis et al., 2010). But there are costs associated with the transition. In the infrastructure sector, some of the most significant are the cost of developing, acquiring, absorbing and producing new technologies, and the cost of retrofitting or replacing polluting infrastructure. Further, although in many cases the cost of renewable energy has been found to be competitive with fossil fuel energy (World Bank, 2010a), renewable energy production has high up-front costs which many developing countries will find difficult to finance, and reliance on renewable energy sources alone cannot feasibly fulfil the very rapidly growing demand for energy in middle income countries.

The extent to which imposing emissions limitations on relatively high emitting developing countries would compromise their developmental agendas is a topic of fierce debate, and depends upon individual country contexts. China, for example, has strong incentives to prioritise green growth independently of the climate change agenda; a recent report from the World Bank estimates that pollution due to rapid and relatively unregulated industrialisation costs China approximately 6% of its GDP every year (World Bank, 2007). In addition, international mitigation strategies create economic opportunities for developing countries (and particularly for more industrialised developing countries), as well as risks. For example, developing countries may be able to utilise international financial transfers and foreign direct investment resulting from carbon markets to advance their economies using green technologies, and may be able to take advantage of new international markets for green products (discussed in detail in section 7). China provides an example of a country that is successfully taking advantage of these opportunities; to date China has received 50% of total CERs from the CDM, and it has thriving wind and solar energy industries. However, emissions limitations also create threats to growth. In China, for example, emissions limitations will compromise the cheap production of energy using indigenous coal reserves; currently a key enabler of continued rapid growth.

The extent to which more industrialised developing countries will be able to continue to grow in a carbon constrained world depends to a significant extent on their

¹⁶ The World Bank's 2010 World Development Report summarises the eventual aim of international negotiations thus: "Looking forward, stabilizing temperatures will require a global mitigation effort. At that point carbon will have a price worldwide and will be traded, taxed, or regulated in all countries." (2010a, p.271).

governments' capacity to design economic policy so as to take maximum advantage of the opportunities, and avoid the risks created by international mitigation strategies¹⁷.

The situation for the poorest countries is quite different. Policymakers in countries with largely agrarian economies, slower growth rates, and very low emissions (characteristic of many countries in sub-Saharan Africa for example) would naturally assign less importance to delinking emissions from growth, and would be disinclined to invest scarce public funds in green growth strategies. Many of these countries are at high risk from climate change impacts, and would understandably prioritise adaptation. In addition the imposition of emissions limitations in international negotiations is a distant prospect for these countries. But many argue that even the poorest countries stand to gain in the long-term by integrating mitigation considerations into policy decisions in the short-term, for three main reasons. Firstly, the development of a low-carbon growth strategy would open doors to the funding, technology and technical assistance created by international efforts at mitigation (discussed further in section 7). Secondly, integrating low-carbon objectives into growth strategies starting from a low level would guarantee the sustainability of development in the long term, since countries that become more affluent using a high-carbon model will eventually face emissions limitations

¹⁷ Their growth opportunities will also depend upon rates of technological development and the level of support they receive from the developed world.

that could dampen growth rates¹⁸. Finally, many policies designed to move countries onto a low-carbon developmental path are 'low-regrets' options, that cost the economy little or nothing. These are policies related to 'developmental paths', as discussed in section 2.2.3. Examples include planning denser cities to avoid high emissions from transportation (with the developmental synergy of shorter travel distances within the city and less air pollution), and developing renewable energy sources where the cost is similar or less than fossil-fuel energy.

Poorer countries would need to ensure that any mitigation policies adopted also generate development and poverty reduction benefits. There is, however, little systematic evidence available to date of the developmental benefits of switching from high-emissions development to low-emissions pathways (Mitchell & Maxwell, 2010). Compiling this evidence, as well as evidence on the policy frameworks that optimise these developmental outcomes, is one area in which donors could encourage and support the development of mitigation strategies in countries that are not facing emissions limitations in the short term. However, even if this evidence can be made available,

¹⁸ The point in time at which carbon will be priced in poorer countries is highly uncertain. It depends in part on the outcome of international negotiations, which may accelerate as climate change impacts becoming increasingly manifest in the coming decades. But it is also depends upon countries' own rates of growth, since imposing limitations that are in any way punitive on very poor countries with slow growth rates will remain politically unacceptable for the foreseeable future.

capacity and financial barriers make the development of low-carbon growth policy frameworks in many low-income countries an aspiration which is difficult to realise as discussed in sections 4 and 6.

Meanwhile, developed countries have recognised their responsibility to reduce their own emissions and finance global emissions-reductions strategies in UN negotiations through the principle of "common but differentiated responsibility" (see Box 3), but progress towards turning this principle into a binding global agreement is slow.

Box 3: Common but differentiated responsibility in the pursuit of sustainable development

"In view of the different contributions to global environmental degradation, States have common but differentiated responsibilities. The developed countries acknowledge the responsibility that they bear in the international pursuit of sustainable development in view of the pressures their societies place on the global environment and of the technologies and financial resources they command."

(Rio Declaration on Environment and Development, 1992 United Nations "Conference on Environment and Development" (UNCED))

2.2.3. Developmental paths influence future capacity to cope with climate change

Developing countries' capacity to cope with both emissions reductions and climatic impacts depends to a great extent on the developmental paths they adopt. A broad range of developmental choices – in which infrastructure policy plays a key role – impact climate change outcomes.

They include: economic structure, technology, geographical distribution of activities, consumption patterns, urban design and transport infrastructure, land use, demography, institutional arrangements, trade patterns, poverty reduction and energy security (Sathaye et al., 2007).

Countries will be best placed to avoid becoming 'locked-in' to high carbon growth patterns, and to minimise negative climatic impacts, if they are able to mainstream mitigation and adaptation objectives routinely into policy decisions across a broad spectrum. Countries' ability to successfully develop and

mainstream climate policy will depend to a significant extent on their institutional structures and whether they are able to develop a coherent climate change policy framework, points which are discussed in more depth in section 6.

Section 2: Summary of key points

Climate change

- The Intergovernmental Panel on Climate Change (IPCC) has predicted that the earth will be 1.8°C to 4°C warmer by the end of the 21st Century compared to the end of the 20th Century.
- The principal cause of global warming is human activity that releases greenhouse gases into the atmosphere, particularly the burning of fossil fuels.
- Two degrees centigrade is widely considered the maximum temperature increase to avoid irreversible damage to global climate and ecosystems, but it is now highly unlikely that temperatures will be stabilised at or below this level.
- Projected impacts include increased precipitation, more frequent extreme weather events, flooding, drought, sea level rise, the collapse of ecosystems and increased disease burden at lower latitudes.

Climate change and development

- Developing countries bear little historic responsibility for the emissions that are causing climate change, but stand to suffer the most severe consequences, for three main reasons. Firstly, climatic impacts will be more acute at lower

latitudes where most developing countries are located. Secondly, developing countries are more dependent on climate-sensitive sectors such as agriculture and fishing. Finally, poorer countries have lower capacity to adapt due to their weaker institutions, lower human and financial capital, and constrained access to technology and credit (Burton et al, 2006).

- Historically, economic growth has been linked with increased GHG emissions. Developing countries will need to break this link if they are to experience rapid growth in a carbon-constrained world; they will need to 'leapfrog' the polluting production methods used by the developed world and move straight to low-carbon growth paths. But there are massive financial, technological and capacity challenges associated with achieving this.
- The relative importance governments assign to adaptation and mitigation will depend on their stage of economic development among other factors. In general, less developed countries will place greater emphasis on adaptation in the short-term, while more industrialised countries will need to devote significant resources to

rapidly developing strategies to reduce current and future emissions, while also countering the negative effects of new climatic conditions.

- However, many would argue that it is also in the best interests of lower-income countries to integrate mitigation considerations into policy decisions at the earliest possible stage. This would enable these countries to benefit from opportunities created by international mitigation strategies, such as access to new sources of finance, and set their countries on growth paths which are sustainable in the long-term. There is, however, little systematic evidence available to date of the developmental benefits of switching from high-emissions development to low-emissions pathways (Mitchell & Maxwell, 2010).
- Developing countries' capacity to cope with both emissions reductions and climatic impacts depends to a great extent on the developmental paths they adopt. A broad range of developmental choices impact climate change outcomes, including geographical distribution of activities, urban design and transport infrastructure, land use, and energy security.

3. How Climate Change will affect the Infrastructure Sector in the Developing World

Climate change has profound implications for the infrastructure sector. This section starts by discussing how the pursuit of low carbon growth paths will affect infrastructure development (3.1), goes on to discuss how climate change impacts will affect baseline infrastructure and generate a need for dedicated adaptation infrastructure (3.2) and finishes with a discussion of the challenges of developing a balanced portfolio of mitigation and adaptation activities in the infrastructure sector (3.3).

3.1. Mitigation in the infrastructure sector

Over half of global GHG emissions are associated with the infrastructure sector (see Figure 2), so progress in reducing infrastructure-related emissions is crucial to global efforts to avoid irreversible damage to global climate and ecosystems. In contrast to the developed world, much of the residential and industrial capital of developing countries is yet to be built, and many developing countries are currently in a phase of massive infrastructure development¹⁹ (World Bank, 2010a; UNFCCC, 2007). This situation presents a unique opportunity for countries to leapfrog high-carbon production methods and move straight to a low-carbon economy. Put another way, developing countries can potentially avoid the expensive adjustment process that rich countries will need to engage in to reduce emissions, and steer

investments that would have occurred in any case towards low-carbon options. But countries that are not able to take advantage of this opportunity face a corresponding set of risks. Where infrastructure deficits are met by investing in high-emissions assets, the long life span of infrastructure investments would result in countries becoming 'locked in' to high carbon growth paths for generations. This would have grave consequences for the planet, but could also eventually constrain economic growth since countries that become more affluent using a high-carbon model will eventually face emissions limitations that could dampen growth rates.

This section gives a brief outline of current thinking on the actions required to reduce emissions in the energy, transportation, and buildings sectors – the sectors with highest emissions – as well as in the manufacture of construction materials.

Efforts to reduce emissions from the energy sector are grouped into three categories: reducing demand (greater efficiency, changing human behaviour, adopting developmental pathways that require less energy); fuel switching (cleaner fossil fuels, from fossil fuels to renewables and nuclear); carbon capture and storage (Fisher et al., 2007, p.222). Today, 80% of energy needs are met with fossil fuel sources (UN-DESA, 2009f), and many of the technologies that will be required to make the transition to global green energy do not yet exist, are still under development, or are not cost-competitive with fossil fuel technologies. Governments will play a key role in creating the incentives for green energy innovation

(discussed further in Section 4.2), and governments and international institutions will need to support diffusion of technological innovations across borders (discussed further in section 5.2). The rate of technological development in the energy sector will directly influence the ability of countries to grow while restricting their carbon emissions (World Bank, 2010d).

In the transportation sector, the magnitude of emissions depends on three factors; the design of vehicles, the fuel they use, and the transport infrastructure provided (World Bank, 2010a). Cleaner fuel sources and more efficient engines play a key role, but achieving emissions reductions on the scale required will also depend upon the development of infrastructure that enables 'modal shifts' to forms of transport that produce less emissions (e.g. from road to rail, from private vehicles to public transport), and supports the minimisation of the number and length of journeys (e.g. careful urban planning, efficient freight routes). Transport activity is currently increasing, particularly in the developing world. Under a 'business as usual' scenario, total energy use and carbon emissions from transportation is projected to increase by around 80% between 2007 and 2030, while the share of emissions from non-OECD countries is projected to rise from 36% to 46% (Khan Ribero et al, 2007). Increased transportation activity is closely allied to economic growth and development, so policies that aim to significantly restrict activity in the sector are not desirable or politically feasible.

¹⁹ Global investment in new physical assets is projected to triple between 2000-2030, and much of this will take place in the developing world (UNFCCC, 2007).

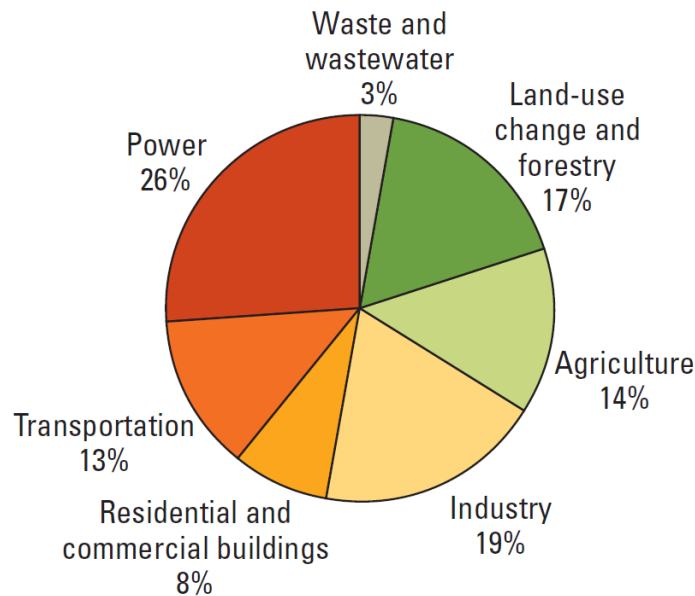


Figure 2: Global greenhouse gas emissions by sector - 2004 figures (CO₂ equivalent)

Source: IPCC 2007c Figure 2.1, quoted in World Bank, 2010a

Technological and planning solutions will be required. Box 4 describes an example of successful urban planning for emissions reductions in the city of Curitiba, Brazil.

Of the four sectors covered here, the buildings sector has the greatest potential for rapid and significant GHG emissions reductions. The IPCC estimates that there is potential to reduce buildings emissions by 29% from the projected 2020 baseline using ‘cost-effective’ investments, i.e. investments that will result in a net saving over the building’s lifetime (Levine et al., 2007, p.389). Emissions reductions will be achieved principally through improving energy efficiency in new and existing buildings (80-85% of building energy use occurs during operation (UNEP, ILO, IOE, ITUC, 2008a)), using technologies that already exist and have been successfully deployed. These include passive solar design, highly efficient ventilation and cooling systems, solar water heating, and insulation. Additional options include reducing the embodied

energy in building materials²⁰, using cleaner fuel sources, reducing non-CO₂ emissions and influencing occupant behaviour (Levine et al., 2007). Many tried, tested, and cost-effective technologies have not yet been widely adopted – particularly in the developing world - due to market and information barriers (Levine et al., 2007). Market barriers are summarised in Table 1, alongside examples of government policies that have successfully reduced CO₂ emissions from buildings. Technological innovation is also needed in the buildings sector to realise emissions reductions on the required scale, particularly developing technologies for retrofitting existing buildings for greater energy efficiency.

A further important barrier to progress in reducing emissions from buildings is limited capacity in the

²⁰ Increased use of traditional and/or indigenous building materials could contribute to achieving this (CIB & UNEP-IETC, 2002).

construction industry, resulting in poor responsiveness to public policy initiatives (CIB & UNEP-IETC, 2002). Architects and engineers worldwide are unaware of materials, designs and techniques available for energy efficient buildings, while the best techniques cannot be implemented in some developing nations due to the low skill levels of construction workers: “while much of the attention focuses on technology, experience demonstrates that the weakest link in the production chain will determine the level of performance that can be attained” (UNEP, ILO, IOE, ITUC, 2008b, p.19). Construction industry clients may also be ‘weak links’; clients (including governments) potentially play an important role in creating an enabling environment for green construction by including sustainability criteria into procurement policies and procedures, but low awareness of the risks and limited capacity within the sector often results in sustainability criteria receiving little attention (CIB & UNEP-IETC, 2002).

Market barriers to reduced GHG emissions in the buildings sector	Government policies to stimulate adoption of green building technologies
<ul style="list-style-type: none"> • High cost of information on green building technologies • Low awareness amongst landlords and tenants • Limited access to finance for up-front investments • Subsidies on the cost of energy • Fragmentation of the building industry and the design process into many stages and professions, and informal and formal sectors 	<ul style="list-style-type: none"> • Updated and enforced building energy codes • Energy pricing measures and financial incentives • Public sector initiatives including procurement policies, education, training and awareness raising for industry and the public

Table 1: Incentivising emissions reductions in the buildings sector: market barriers and government policies

Source: Levine et al., 2007

Box 4: Case study: Urban planning for mitigation and sustainable development in Curitiba, Brazil		
<p>Cities offer considerable opportunities to reduce CO₂ emissions when applying coordinated approaches to emission reductions in transport and buildings. Curitiba's municipal authorities have been implementing innovative approaches in urban planning, city management, and transport planning going back as far as the 1960s, in particular a 'radial linear-branching</p>	<p>pattern', which served to protect both density and green areas. Through a combination of land-use zoning and provision of public transport infrastructure, Curitiba has achieved the highest rate of public transport use in Brazil (45% of journeys), and one of the country's lowest rates of urban air pollution. Curitiba's fuel usage is 30% lower than in Brazil's other major</p>	<p>cities, while the per capita loss due to time spent in severe congestion in Curitiba is approximately 11 and 7 times less than Sao Paulo and Rio de Janeiro respectively.</p> <p>Source: UNEP Green Economy Success Stories: http://www.unep.org/greeneconomy/SuccessStories/SustainableUrbanPlanninginBrazil/tabid/29867/Default.aspx</p>

Finally, enforcing energy efficiency standards through revised codes of practice is very challenging in countries where informal construction is widespread, and where many small and medium construction operatives are not formally registered (CIB & UNEP- IECT, 2002).

Including sustainability criteria and creating and implementing environmental regulations increases project costs. In the case of climate change there is a powerful argument that developing country governments should not be expected to apply regulations that increase project costs unless they are receiving adequate compensation from richer countries. At present, the costs associated with green policy in the infrastructure sector in the developing world are little understood. Gaining an

improved understanding of these costs would enable mechanisms to be put in place to compensate developing countries either through public donor funds, or through private funds through carbon markets.

Manufacturing the materials that make up the built environment also makes a significant contribution to GHG emissions. Cement and steel are wholly (in the case of cement), or largely (in the case of steel) destined for use in the construction industry, and contribute about 4% and 6% of global GHG emissions respectively (McKinsey & Company, 2009). Compared with other industries, they also have high emissions reduction potential (Bernstein et al., 2007). A high and growing proportion of cement and steel production takes place in the

developing world²¹, but many production facilities are outdated, inefficient and polluting. There is an urgent need for transfer of existing technologies to improve energy efficiency and reduce emissions associated with energy production and, in the case of cement, emissions associated with the chemical reactions that occur during manufacture. Increased recycling of construction materials, particularly steel, also has the potential to deliver significant emissions reductions (UNEP, ILO, IOE, ITUC, 2008a). Finally, carbon capture and storage is also projected to make an important contribution to reducing

²¹ For example, in 2003, developing countries accounted for 78% of cement manufacture and 42% of iron and steel production (Bernstein et al., 2007, p.449).

emissions from cement and steel production when it comes online (currently predicted to occur around 2020) (McKinsey & Company, 2009). Barriers to the introduction of green technologies in the manufacture of construction materials include: lack of incentives created by the market or government regulations; the slow rate of capital stock turnover; lack of technical and financial resources; limited capacity of firms to absorb technology transfer (Bernstein et al., 2007).

While there are powerful arguments in favour of developing countries integrating policies and practices to reduce emissions as an essential component of their infrastructure investment at the earliest possible stage, there are many barriers to realising this aim. Indeed, most developed countries are a long way off meeting their mitigation targets despite their greater capacity. Barriers in developing countries include lack of capacity, limited access to the latest technologies and limited financial resources. They are discussed in greater detail in sections 4, 5, and 6.

3.2. *Adaptation in the infrastructure sector*

New climatic conditions resulting from global warming will affect the infrastructure sector through two main channels. First, the changing climate will need to be taken into account in the location, planning, design, construction, operation and maintenance of baseline infrastructure across the spectrum. Climate change will result in an overall increase in costs for baseline infrastructure as: some prospective sites become unviable; new facilities are constructed to be more resilient; operation, maintenance and insurance costs increase; and some infrastructure requires retrofitting to withstand climate change impacts

(World Bank, 2010c). Investors may also choose to design infrastructure with the possibility of mid-life adjustment, as a response to the prevailing uncertainty around climate change impacts (Fankhauser et al., 1999).

Second, a range of dedicated adaptation infrastructure will be required. This includes coastal zone protection to withstand sea level rise (for example sea and river dikes and port upgrades); riverine flood protection; and water supply and agricultural infrastructure in areas suffering drought or saline intrusion (World Bank, 2010c).

This section starts by exploring approaches to integrating climate change impacts into baseline infrastructure investment decisions, and the associated challenges. The example of climate risks to coastal mega-cities is used to illustrate the urgency of taking action. This is followed by a discussion of approaches to investment decisions in the field of dedicated adaptation infrastructure, exploring the challenges inherent in combining evaluations of climate risks with assessments of the vulnerability and adaptive capacity of populations, as well as the importance of combining hard infrastructure investments with 'soft' interventions such as community capacity building and education. Some fundamental framing concepts around the timing and approach to adaptation decisions are then summarised in Box 6. The section finishes by outlining how investments in improving basic infrastructure (with no explicit relation to climate change) can promote development and thus enhance adaptive capacity, and so can be seen as one form of adaptation.

Infrastructure investments have a long life-time, so most baseline

infrastructure projects currently at planning stage will be affected by future climatic change, and many would be very costly to modify post-completion (OECD, 2009). As discussed in the context of mitigation, the current underdevelopment of infrastructure in the developing world, combined with the rapid rate of accumulation of physical assets in many countries, creates a critical window of opportunity to develop a climate-resilient stock of infrastructure. A model response would see public and private infrastructure investors across all sectors and continents acting quickly to integrate climate risk assessment into project planning and investment decisions (Burton et al., 2006). Abiding financial and capacity constraints create barriers to rapid action, but the task also is complicated by the uncertainty surrounding the magnitude and geographical distribution of climate change impacts, and the timeline associated with their onset (World Bank, 2010d). A risk-based approach is the ideal response to this uncertainty; such an approach would evaluate the probability and impact of a spectrum of possible outcomes against the cost of mitigating them (World Bank, 2009). In the case of public investment, assessments of climate risks should be combined with assessments of vulnerability and adaptive capacity of populations at risk to make decisions on the appropriate distribution of scarce public funds (World Bank, 2010e). However, both climate data and human and technological capacity to carry out this type of risk assessment are in short supply in many developing countries (Mugabe et al., 2000).

Capacity to develop, monitor and enforce construction regulations

designed to prevent maladaptation in the development of baseline infrastructure – for example around land use and construction standards – is also often lacking. This is due to low capacity in government, particularly at local level, and to the prevalence of informal construction and poor transparency in permit award procedures (CIB & UNEP-IECT, 2002; UN-DESA, 2009f).

Despite the prevailing uncertainty, certain decisions are clearly cost-effective. Changing design standards for baseline infrastructure to allow for increased precipitation and more frequent extreme weather events, and subjecting long-lived infrastructure investments to climate-robustness assessments, are relatively inexpensive measures with the potential to significantly mitigate climate risk to infrastructure investments. These measures can be achieved through programmes such as the ‘Mainstreaming adaptation to climate change in the Caribbean Community’ project described in Box 5.

Donors could play an important role in supporting the process by integrating climate risk assessments into project planning for donor supported infrastructure projects. Nearly half of the international financial institutions’ project lending to developing countries goes to infrastructure (ECG, 2007). By adopting climate risk screening as standard, donors would protect their investments, but also make an important contribution to generating the tools and knowledge needed for developing country partners to do the same. Progress has already been made by some institutions, and pilot tools are already available²², but donor

²² For example the World Bank’s *ADAPT* (Assessment & Design for Adaptation to

organisations have a long way to go before climate screening is standard across all infrastructure investments.

The risks faced by many of the developing world’s rapidly expanding cities illustrate the urgency of integrating climate change into infrastructure investment decisions. Cities on the coast are particularly vulnerable, but continue to swell due to high rates of urbanisation. By 2015, it is projected that there will be 15 coastal mega cities (defined as cities with populations greater than 8 million) in the developing world²³ (Klein et al., 2003). Climate change puts these cities at risk of erosion, storm and wind damage, flooding and salinisation of surface waters (Klein et al., 2003), risks which infrastructure planners will need to incorporate into designs and investment decisions. It is likely to be the most vulnerable who are most at risk, particularly those living in informal settlements which often develop in high-risk areas such as river banks and unstable hill slopes (UN-DESA, 2009e). Again, capacity constraints in municipal governments are an obstacle to successful urban adaptation in many cases: “most of the risk to urban areas is associated with the incapacity of local governments to,

Climate Change: A Prototype Tool), and UNDP’s *Adaptation Learning Mechanisms (ALM)* by UNDP. Further information is available via the World Bank’s ‘Climate Change Data Portal’: available at: http://sdwebx.worldbank.org/climateportal/doc/Climate_change_Portal_USERS_MANUAL.pdf [accessed 28th Feb, 2011]

²³ These are: Bombay, Lagos, Dhaka, Karachi, Jakarta, Calcutta, Metro Manila, Shanghai, Buenos Aires, Cairo, Rio de Janeiro, Tianjin, Bangkok, Lima and Madras.

inter alia, ensure the development and protection of infrastructure and the adequacy of disaster risk reduction and disaster preparedness” (UN-DESA, 2009f, p.xiv).

Investments in dedicated adaptation infrastructure are also framed by uncertainties around climate risks and people’s vulnerability. Dedicated adaptation infrastructure such as sea and river dykes will be funded largely from public sources (see section 4.3), so public authorities will be largely responsible for deciding the optimal distribution of scarce resources to protect populations and the economy. Vulnerability to climate impacts is a function of three factors: *exposure* to risk, *sensitivity* to that risk, and *adaptive capacity* (IPCC, 2007; quoted in World Bank 2010d). Ideally, public investments would be made on the basis of a joined-up assessment of these three factors, but accurate information on the vulnerability and adaptive capacity of at-risk groups is scarce, and climate impacts remain uncertain. The prevailing wisdom is to opt for investments that are robust under most climate scenarios until better information is available (World Bank, 2010d). These are often termed ‘no regrets’ or ‘low regrets’ options, and are typically investments that are priorities for development even without climate change.

In order to meet the needs of the poorest and most vulnerable, it will be important to combine ‘hard’ approaches (i.e. physical infrastructure) with interventions aimed at building capacity and resilient livelihoods. The importance of achieving this balance is demonstrated by the views of participants in a series of workshops on adaptation carried out by the

World Bank in six developing countries: “[i]nfrastructure investments were perceived to be insufficient if complementary efforts were not made to promote capacity building, institutional development, and in many cases, fundamental

transformation to underlying logic and livelihood strategies” (World Bank, 2010e, p.47). By way of example, Figure 3 lists the hard, soft, autonomous and planned needs identified in the workshop in Mozambique.

Box 6 below sets out some further important concepts that frame decisions around infrastructure investment related to climate change adaptation.

Box 5: Case study: Mainstreaming adaptation to climate change in the Caribbean Community (CARICOM)

The Mainstreaming Adaptation to Climate Change (MACC) project, funded by the Global Environment Facility (GEF), implemented by the World Bank, and executed by the CARICOM Secretariat located in Georgetown, Guyana ran from 2004-2009. The project aimed to mainstream climate change adaptation strategies into the sustainable development agendas of the small island and low-lying states of

CARICOM. One of the project sub-components is ‘Disaster prevention through strengthening technical norms for infrastructure development’, which includes “Completing a study that updates infrastructure design standards to adapt to the impact of climate change, focusing primarily on coastal zones, and that outlines the minimum data requirements for climate projections, required to

establish design standards based on statistical and dynamically downscaled climate projection models”.

Source: CARICOM Secretariat: Mainstreaming Adaptation to Climate Change (MACC) Project Components
http://www.caricom.org/jsp/projects/macc%20project/macc_components.jsp [Accessed 21st March 2011]

	Planned Adaptation	Autonomous Adaptation
Hard	<ul style="list-style-type: none"> • Flood control dikes and levies • Coastal flood control gates • Dams and irrigation channels • <i>Improved roadways</i> • <i>Improved communication infrastructure</i> • <i>Improved hospitals and schools</i> 	<ul style="list-style-type: none"> • More robust buildings • Farm-scale water storage facilities • Deep wells to provide drinking water for people and animals • <i>Grain storage facilities</i> • <i>Improved food processing equipment</i>
Soft	<ul style="list-style-type: none"> • Improved early warning of climatic hazards, and of dam releases • Better planning and management of forest, fish, and other natural resources • Resettlement of populations to lower risk zones • <i>More credit and financial services for small businesses and rural development</i> • <i>Better education and information for the rural areas</i> • <i>Improved health care, social services, and social support for all people</i> 	<ul style="list-style-type: none"> • Better utilization of short season and drought resistant crops to prepare for drought, floods, and cyclones • Diversification of flood and drought risk by maintaining fields in both highland and lowland areas. • Better household and community management and use of natural resources, including wild fruits • Practice of soil conservation agriculture • Migration to lower risk areas • <i>Diversification of livelihoods away from agriculture</i> • <i>Better planning of how much grain to save for personal consumption, and how much to sell for income generation</i>

¹The options in plain text respond directly to climate hazards, while those in italics represent measures to increase the adaptive capacity of the population, or to make them more resilient to shocks to their livelihoods in general.

Figure 3: Hard, soft, planned and autonomous adaptation options

Source: World Bank 2010e, p.47

Box 6: Adaptation framing concepts

Anticipatory adaptation takes place before impacts become apparent, whereas **reactive** adaptation takes place afterwards.

Private adaptation (also called 'autonomous' adaptation) is funded and implemented by private individuals or firms, whereas **public** adaptation is funded and implemented by a public agency. (Adejuwon et al., 2001)

Approaches to adaptation can be classified as (Smit et al. 2001):

Planned Retreat: for example physically moving human settlements away from rising seas, flooding rivers, and areas experiencing very high levels of water stress

Accommodation: accommodating to the changes, e.g. raising houses on stilts or plinths, improved water storage and distribution

Protection: for example constructing dykes and dams to protect human settlements

Maladaptation: An action or process that increases vulnerability to climate change-related hazards. Maladaptive actions and processes often include planned development policies and measures that deliver short-term gains or economic benefits but lead to exacerbated vulnerability in the medium to long-term (UNDP, 2010a). An example is the construction of a new settlement in an area that is likely to be vulnerable to future flooding.

Beyond infrastructure investments dedicated specifically to coping with climate change impacts, baseline levels of infrastructure also make an important contribution to countries' and communities' adaptive capacity. Improved infrastructure is a key factor in enabling countries to diversify their economies away from sectors that are highly vulnerable to climate change, such as agriculture, and in reducing the vulnerability of the poorest. Further examples from the literature include: in urban areas, poor water, sanitation and transport infrastructure renders residents of informal settlements highly vulnerable to deteriorations in their circumstances due to climate change (OECD, 2009); communities and households located in rural areas may be more vulnerable if road networks are underdeveloped and access to markets, schools and public services is limited (World Bank, 2010e). Improved infrastructure also supports government capacity-building - a key element of climate change capacity building - by improving the efficiency and effectiveness of central and local governments, and supporting public participation in democratic processes (UNDP, 2005). Investing in baseline levels of infrastructure

could therefore be seen as contributing to climate change adaptation in many cases.

3.3. Finding a balance between mitigation and adaptation

Different countries prioritise adaptation and mitigation differently, as discussed in section 2.2.2. However, all countries will need to include elements of both in their infrastructure-related climate policy in the long-term, and many need to do so in the immediate future. Finding a balance between the two, and balancing climate-related activity with developmental priorities, is highly complex, not least because adaptation and mitigation in the infrastructure sector require very different approaches, affect different sectors, and have differing uncertainties and distributions of benefits, summarised in Table 2.

In order to develop an integrated adaptation-mitigation portfolio, it will be important to consider synergies and trade-offs between investing in adaptation or mitigation, the interaction effects between options, and the impact on development. Investments in adaptation or mitigation may be *alternatives* in reducing costs, they

may be *complementary* (for example investing in building energy efficiency cuts emissions and improves capacity to cope with temperature extremes), or they may be *competing* and mutually contradictory (for example coastal defence vs. reductions in sea level rise) (Willbanks & Sathaye, 2007, p.958). Some investments may also have unintended consequences, for example equipping buildings with improved air conditioning systems to cope with higher temperatures may increase energy consumption, and thus emissions. Applying risk tools and techniques can support the development of an integrated portfolio, in which those options with complementarities and synergies between mitigation and adaptation (and development) are prioritised.

Information needs for the development of an integrated portfolio are enormous; they include fine-grained climate forecasting, as well as a range of information about the interactions between mitigation, adaptation and development, and an understanding of the associated uncertainties (Willbanks & Sathaye, 2007). Limited financial resources also narrow the range of available options: "the availability of financial

resources for risk management often dominates decision-making, regardless of the results of risk analysis” (*ibid*, p.962).

By way of summary, Table 3 provides some examples of the type of investment in physical infrastructure that will be required

as a result of climate change for both mitigation and adaptation. While a great deal of research on climate change and development has been carried out this has, to date, yielded little in the way of practical “policy guidance on how countries might manage transformative change” (UN-DESA,

2009f, p.4) or “concrete models and approaches” (Bapna & McGray, 2008, p.12). The development of decision making frameworks to help countries prioritise the investments listed in Table 3 would be one approach to support developing country policymakers in coping with these complex decisions.

	Mitigation	Adaptation
Approach	Emphasis on top-down, centralised decision-making.	Greater scope for bottom-up approaches in which communities play a central role, and decentralised decision-making.
Distribution of benefits	Worldwide	Specific locale of investment
Principal uncertainties	Rate of technological change. Outcomes of international negotiations.	Climate impacts and their time horizons. Potential for autonomous adaptation.
Infrastructure sectors	Energy, transportation, buildings, industry.	Baseline infrastructure across all sectors. Dedicated adaptation infrastructure: coastal, water, agricultural.

Table 2: Mitigation and adaptation: differences in approach, benefits, uncertainties and sectors

Sources: Willbanks & Sathaye, 2007; World Bank, 2010a

Mitigation	Adaptation
<p>Energy</p> <ul style="list-style-type: none"> • fossil fuels: improved efficiency, switch from coal to gas, technological advances reducing GHG emissions • carbon capture and storage • renewable (including decentralised networks) • nuclear <p>Transportation</p> <ul style="list-style-type: none"> • improved public transport, especially in urban areas • more efficient freight transport infrastructure <p>Buildings</p> <ul style="list-style-type: none"> • reduced energy usage throughout the life cycle, but particularly during operation - heating, cooling and lighting <p>Materials manufacture</p> <ul style="list-style-type: none"> • improved energy efficiency and reduced carbon emissions through technological advances • use of materials with lower embedded carbon 	<p>Constructing, operating and maintaining baseline levels of infrastructure services under new conditions (including retrofitting).</p> <p>Better land use planning</p> <p>Dedicated adaptation infrastructure, including:</p> <ul style="list-style-type: none"> • Coastal zone protection: sea dikes, river dikes, port upgrades • Water supply infrastructure (for household, agricultural and industrial use) for areas suffering drought or saline intrusion • Riverine protection such as dikes and dams to prevent flooding and adapt to variability in runoff • Improved transport and storage in areas that experience food shortages due to drought or flooding.

Table 3: Examples of investment in physical infrastructure required as a result of climate change

Sources: World Bank, 2010c; World Bank, 2009; Davidson et al., 2003; Fankhauser et al, 1999

Section 3: Summary of key points

Mitigation

- Over half of global GHG emissions are associated with the infrastructure sector, so progress in reducing infrastructure-related emissions is crucial to global efforts to avoid irreversible damage to global climate and ecosystems.
- Key infrastructure sectors for mitigation are energy, transport and buildings. The manufacture of construction materials also makes up a significant share of global emissions.
- Of these four sectors, the buildings sector has the greatest potential for rapid and cost-effective emissions reductions, often using existing technologies. But action is severely sub-optimal due to market and information barriers, low awareness amongst landlords and tenants, limited access to finance, and the fragmentation of the construction industry.
- In the energy sector, emissions reductions will be achieved by reducing demand, switching to cleaner fuels, and carbon capture and storage (Fisher et al., 2007). The rate of technological development in the energy sector will directly influence the ability of countries to grow while restricting their carbon emissions (World Bank,

2010d). Technology transfer will also play a key role in reducing emissions from the manufacture of cement and steel (Bernstein et al., 2007), as will carbon capture and storage. In the transportation sector, technical and urban planning solutions will be required to reduce emissions without compromising economic growth and other developmental goals.

- Action in the infrastructure sector is urgent as infrastructure assets have a long life span. Countries experiencing rapid growth face a critical window of opportunity to develop a low-carbon stock of infrastructure, or risk becoming 'locked-in' to high-carbon growth paths for generations.

Adaptation

- New climatic conditions will affect the infrastructure sector through two main channels. First, the changing climate will need to be taken into account at every stage of the project cycle for baseline infrastructure. Climate change will result in an overall increase in costs, as some prospective sites become unviable, new facilities are constructed to be more resilient, operation, maintenance and insurance costs increase, and some infrastructure requires retrofitting to withstand climate change impacts

(World Bank, 2010c).

- Second, a range of dedicated adaptation infrastructure will be required, including coastal zone protection to withstand sea level rise, riverine flood protection, and water supply and agricultural infrastructure for areas suffering drought and saline intrusion.
- The task of adapting the infrastructure sector to climate change is complicated by a high degree of uncertainty around future impacts. But certain actions are clearly cost effective. These include changing design standards and submitting long-lived infrastructure to climate-robustness assessments.
- In order to meet the needs of the poorest and most vulnerable, it will be important to combine 'hard' approaches (i.e. physical infrastructure) with interventions aimed at building capacity and resilient livelihoods.
- Most infrastructure currently being planned will be affected by climate change, so the mainstreaming of climate risk assessments into infrastructure planning is urgent in order to avoid negative outcomes ranging from sub-optimal investment, to poorly performing infrastructure, to catastrophic failures.

4. Key Challenge 1: Finance

Realising the actions described in the previous section requires a massive volume of funding. Estimates of the total *annual* funding needed in developing countries between 2010 and 2030 vary between \$300 billion and \$565 billion for mitigation, and between \$4 billion and \$105 billion for adaptation (World Bank, 2010a). Much of this funding is required in the infrastructure sector (see section 9.1). Given the global distribution of responsibility for emissions, and the distribution of wealth, there is a powerful argument for the vast majority of this funding to be supplied through transfers from developed countries. In any case it is far beyond the capacity of most developing countries to raise funding on the scale required.

Finance for climate-related infrastructure investment in the developing world is currently being made available through donor funding and carbon markets, but is inadequate by a large margin. A recent assessment by the World Bank estimates annual funding available from Official Development Assistance (ODA – grants and loans) and the CDM for mitigation from 2008 - 2012 at less than \$8 billion a year, and funding for adaptation at less than \$1 billion per year (World Bank, 2010a). Costs will only increase if action is delayed (Stern, 2006), so it is crucial to scale-up the available funding rapidly and significantly.

This section starts by discussing current mechanisms and agreements designed to promote the transfer of funds from the developed to the developing world, followed by a discussion of options for scaling up these funding flows (section 4.1). Section 4.2 explores

policies for leveraging domestic finance, and section 4.3 discusses the likely distribution of finance between the public and private sectors to meet infrastructure investment needs associated with climate change.

4.1. Finance from the Global North

Climate change finance can be classified under three categories (UNFCCC, 2007): (1) emissions trading (of which the Kyoto Protocol's Clean Development Mechanism is by far the most significant mechanism for the developing world at the present time); (2) donor funding in the form of grants, concessional loans, and the adaptation levy on CDM transactions²⁴; (3) national policies (i.e. government policies designed to encourage public and private climate-related investment). This section describes how finance is leveraged under categories (1) and (2) and, in the case of the CDM and donor funding, the scale of funding currently available. Shortcomings of the CDM and proposals for reform are also briefly covered in section 4.1.1.

4.1.1. Emissions trading and the Clean Development Mechanism

Emissions trading changes incentives for infrastructure investment and financing; it stimulates a shift to, and additional funding for, less polluting activities and green innovation. Several emissions markets exist, and some middle-income countries such as China are now establishing their own, but the only market

mechanism that currently has real significance for many countries in the developing world is the CDM. Described by the UNFCCC as “a project-based mechanism that feeds the carbon market” (UNFCCC, 2010b), the CDM allows industrialised countries with targets under the Kyoto Protocol to implement emission-reduction projects in developing countries in order to meet those targets. Officially, it has a dual objective: to stimulate sustainable development and to stimulate emissions reductions by enabling richer nations to invest in abatement in countries where the costs are lower (UNFCCC, 2010c). The CDM – along with emissions trading schemes more generally – facilitates a more efficient allocation of mitigation by diverting funding to the cheapest mitigation options, and also facilitates increased investment to developing countries, bringing benefits such as technological spillovers.

The World Bank estimates that, between 2001 -2012, the CDM will raise a total of approximately \$18 billion in direct revenues for developing countries, depending on the price of carbon (World Bank, 2010a). Revenues after 2012 are uncertain, as a post-2012 international climate regime has not yet been established. The continued growth of the CDM is seen by many to be an essential enabler to raising climate finance for developing country mitigation, but the necessary scaling-up of the mechanism is limited by its highly bureaucratic procedures (on average it takes a CDM project 300 days to complete the regulatory process, with transaction costs as high as \$500,000 (Stern, 2009)), as well as

²⁴ There is currently a levy of 2% on the sale of permits in the CDM, the proceeds of which go to the Global Environmental Facility's (GEF's) Adaptation Fund.

the currently lax Kyoto targets and the non-participation of the USA.

Criticism of the CDM is widespread; many would argue that the mechanism should not in any case be scaled up in its current form. One of the principal objections is that the CDM is not achieving its sustainable development objective due to the way in which the market mechanism operates and the limited range of countries and sectors to which CDM finance is flowing.

Of the two stated objectives of the CDM, only the emissions reduction objective is measured by the market; no market value is given to the sustainable development objective. Since competition for CDM investment is fierce, there is evidence that this is leading to a 'race to the bottom', with countries downgrading their sustainable development requirements and making little effort to involve local stakeholders in the project approval process in order to win investment (Sutter & Parreño, 2007; Sterk & Wittneben, 2006).

The distribution of CDM finance is limited to a narrow range of countries. To date China has issued 50% of the certified emissions reductions (CERs); China, India and Brazil together have issued more than 90% of the total; sub-Saharan Africa has issued just 0.4% of CERs, almost all from South Africa (UNFCCC, 2010d). CDM investment is flowing principally to countries that already have relatively strong investment environments. Barriers to poorer countries seeking to attract CDM investment include inadequate investment climates, low levels of industrialisation, and lack of CDM capacity, particularly with regard to institutional architecture (Byigero et al., 2010). Since the CDM is a market-based mechanism,

it is difficult to see this changing in the short-term.

The sectors to which CDM investment is flowing generally have limited direct developmental benefits (Olson, 2007). The top four project types by issued CERs (and expected issuance of CERs up to 2012) are HFCs, N₂O, wind and hydro (CDM Pipeline, 2010). These sectors generate high volumes of CERs per dollar invested, making them attractive to developed world investors. But project in these sectors are more likely to create benefits for people working in skilled jobs, in contrast to projects in sectors such as forestry and small-scale infrastructure which generate a high ratio of unskilled employment per dollar invested, and create immediate benefits for communities. The CDM's bureaucratic and expensive procedures also make investment in small projects unfeasible, but it is often small-scale, community-based projects that bring the greatest direct benefits to the poor (Jahan & McCleery, 2005).

There is also concern that the CDM does not encourage investment in some of the sectors with greatest significance for reducing emissions in the developing world, especially in important infrastructure sectors: "[t]he CDM has not supported any increased efficiencies in the built and household environments or transportation systems, which produce 30% of global carbon emissions and are the fastest-growing sources of carbon emissions in the emerging markets" (World Bank, 2010a, p.266).

Finally, the CDM is an offsetting mechanism, so it may have the negative outcome of discouraging parties in the industrialised world from cutting their own emissions. This would ultimately have severe

negative consequences for developing countries which stand to suffer the greatest impacts from changing climatic conditions.

Multiple approaches have been proposed for reforming the CDM²⁵. One of the most interesting for the infrastructure sector is "sectoral CDM", whereby developing countries would be able to issue CERs for reducing emissions across a sector, as opposed to the current scheme in which CERs are associated with a project. Proponents argue that sectoral CDM would create the right incentives, and the necessary scale of funding, for governments to make structural changes in their economies, and establish the technical capacity to achieve sector-wide transformations to low-carbon growth paths (Sterk & Wittneben, 2006). Further, sectoral CDM would enable previously excluded projects to aggregate to a scale where they become viable in the CDM market, for example projects that create relatively few CERs per dollar invested - although they may have high sustainable development benefits - small scale projects, and projects for which it is difficult to prove 'additionality'²⁶ (Sterk & Wittneben, 2006). A sectoral approach would promote the inclusion of transportation projects, which are currently practically non-existent in the CDM portfolio (see section 9.2.4), as well as increasing funding for renewable energy and

²⁵ See for example Sterk & Wittneben, 2006; Boyd et al, 2009; Olson & Fenhann, 2008.

²⁶ To qualify for the CDM, projects have to prove that they create 'additional' emissions reductions, i.e. that they would not have occurred anyway. This is particularly difficult for transport projects, which have multiple purposes (Sterk & Wittneben, 2006).

energy efficiency projects (Sterk & Wittneben, 2006).

Some different and innovative approaches to offsetting have also been proposed in order to enhance developmental benefits, for example the 'AdMit' carbon offsetting pilot programme, which guarantees a payment directly from polluters to communities in the developing world that are most vulnerable to the impacts of climate change (IIED, 2010).

4.1.2. Donor funding

In terms of quantity, donor funding to date is relatively limited, but it plays an important role. Donor funds are a vital source of support in the poorest countries which have limited resources and struggle to attract private investment. Financial support from donors also facilitates activities such as capacity-building, technology transfer, and risk mitigation which play an essential 'leveraging' role in making the transition to a climate-friendly and resilient world, and have no obvious alternative source of finance. Funding is disbursed through a multitude of bilateral and multilateral funds²⁷ in the form of grants or concessional loans. The following paragraphs provide an overview of the magnitude of funding pledged and deposited to date, pledges of future funding made at the 2009 Copenhagen talks, and a brief description of some of the more important multilateral and bilateral funds.

Up until August 2010, a total of \$27 billion had been pledged by donors to bilateral and multilateral climate change funds (hereafter referred to as 'Climate Funds') and \$9 billion

deposited (Climate Funds Update, 2010). During the Copenhagen climate talks, wealthier nations made a pledge to provide \$10 billion a year from 2010-2012, increasing to \$100 billion a year by 2020. Questions remain over the nature (grants or loans) and additionality (whether it will be additional to aid pledges already made) of the funding, the decision-making processes associated with it, and whether it will in fact materialise (Timmons Roberts et al., 2010).

Of the multilateral organisations, the Global Environment Facility (GEF) and the World Bank play particularly important roles. The GEF is an independent organisation which acts as the designated financial mechanism for a number of multilateral environmental agreements, including the UNFCCC. Donor commitments to the GEF to date for climate change (deposits and pledges) are estimated at \$2.4 billion, from 32 donors (Climate Funds Update, 2010). The GEF is principally focused on mitigation, but it also manages two small adaptation funds for the UNFCCC, these being the Least Developed Countries Fund (LDCF) and the Special Climate Change Fund (SCCF). The two adaptation funds together had received donations amounting to \$400 million by 2010 (GEF, 2010b). The LDCF funds a special programme to support adaptive capacity in LDCs, many of which are highly vulnerable to climate change, but have low levels of adaptive capacity; the programme is named the 'National Adaptation Programmes of Action' (NAPAs). Further explanation of the rationale behind the NAPAs is provided in section 9.2, as well as an analysis of infrastructure project proposals under the NAPAs.

The World Bank established two Climate Investment Funds in 2008, and received pledges of \$6.1 billion from 10 donor countries. The Clean Technology Fund finances demonstration, deployment and transfer of low carbon technologies; the Strategic Climate Fund pilots new approaches with potential for scaling up (Climate Investment Funds, 2010). A key objective of both funds is to leverage private sector funding by reducing climate investment risks.

In addition to these multilateral initiatives, there are several bilateral programmes. The largest by far is Japan's 'Hatoyama Initiative' to which US\$15 billion has been pledged up to 2012 - more than half the total pledged globally from all sources. The majority of funds will be assigned to mitigation projects; little further information is publicly available.

Given the important role played by donor funding and its limited volume, it will be important to make the best use of these funds by exploiting synergies with existing financial flows - including existing aid transfers - and to ensure that donor contributions are well coordinated across sectors, countries and regions (UNFCCC, 2007).

4.1.3. Options for scaling-up North-South flows of climate change finance

The principal options that have been put forward by the international community for scaling up climate finance are described below (World Bank, 2010a; UN-DESA, 2009d; UNFCCC, 2007):

Increased Official Development Assistance (ODA): The group of 77 developing countries and China have suggested that OECD countries give 0.25-0.5% of their annual Gross

²⁷ Refer to www.climatefundsupdate.org for more detailed information.

National Product to a fund devoted to responding to climate change (possibly the GEF), above and beyond their other aid commitments.

Scale up the CDM: Suggestions for scaling up the CDM include sectoral CDM (discussed above), setting more stringent limits on emissions, increasing the number of countries that commit to emissions reductions, and broadening the scope of projects that can be included under the CDM.

International taxes on emissions and / or transport: International taxes would serve the dual purpose of raising finance and creating incentives for green investment.

Raising funds from sales and exchanges of emissions units under the Kyoto Protocol: Countries with commitments under the Kyoto Protocol are issued 'Assigned Amount Units' (AAUs) up to their emissions limitation. A proportion of AAUs could be auctioned to the highest bidder to raise funds for adaptation, or a levy could be introduced on international exchanges of AAUs, similar to the current 2% levy on the CDM.

Additional suggestions include: a tax on currency transactions ('Tobin tax'); debt relief in exchange for a commitment on the part of beneficiary government to invest the savings in green projects; redirecting existing spending, for example on military expenses and subsidies to polluting activities; the use of mechanisms such as advanced market commitments; and the use of innovative financial instruments.

4.2. Domestic finance

In order to meet climate-related infrastructure investment needs, international financial transfers will

need to be combined with developing country national policies to encourage climate-related domestic investment. Such policies would be designed to shift investments and financial flows made by private and public investors to into more climate-friendly and resilient alternatives and encourage investment by spreading risks across private and public investors (UNFCCC, 2007). The UNFCCC report 'Investment and Financial Flows to Address Climate Change' (2007, p.179), identifies the following national investment stimulation policies:

Mitigation

- *Overcoming policy-based barriers to entry:* In the power sector; regulations to encourage provision of power from low carbon sources, removing subsidies to polluting energy production²⁸, and feed-in tariffs²⁹. In general; adjusting standards (for example building codes) that inhibit implementation of lower carbon solutions.
- *Making the polluter pay:* Imposing emissions limits, or imposing taxes or other charges on emissions. Holding polluters liable for the climate damage they cause.

²⁸ However, removal of energy subsidies without with an increase in income or the availability of other affordable energy services could be inequitable and socially unacceptable (UN-DESA, 2009g).

²⁹ A feed-in tariff imposes an obligation on regional or national electric grid utilities to buy renewable electricity from all eligible participants. A feed-in tariff typically includes three key provisions: guaranteed grid access; long-term contracts for the electricity produced; purchase prices that are methodologically based on the cost of renewable energy generation and tend towards grid parity (Mendonça, 2007).

- *Paying the innovator:* Creating tradable emissions rights to reward investments in reducing emissions. Fiscal incentives for investing in reducing emissions. Direct public support (for example funding research and development (R&D)).
- *Filling information gaps:* Requiring (or supporting) disclosure of data on emissions. Providing data to potential investors.

Adaptation

- Providing incentives for private investors to adapt new physical assets to climate change impacts.
- Integrating climate change adaptation into key line ministries.
- Local government adaptation policies in key sectors.

The World Bank (2010a, p.276) adds two further public policies to incentivise adaptation infrastructure investment: regulation, including zone planning and building codes; and education and improved information.

Governments' ability to implement these and similar policies will depend upon their capacity, as discussed section 6.

4.3. Balance between public and private sector funding for adaptation and mitigation

Financing sources, and thus methods of raising finance, are quite different for mitigation and adaptation in the infrastructure sector. There is far greater potential to raise private finance for mitigation than adaptation. Private finance is sourced mainly through carbon markets at the present time, although carbon taxation is likely to play a greater role in incentivising private investment in emissions reductions in future. In contrast, adaptation investment will be sourced principally from public

budgets, although private agents (i.e. households and firms) will also carry part of the burden as they invest in adapting their assets to the future impacts of climate change (World Bank, 2010a).

Worldwide, most emission-producing infrastructure, such as power plants, industrial facilities and buildings, is privately owned. Private owners will increasingly face penalties for producing emissions and reap rewards for reducing emissions as international and national GHG control policies, such as carbon markets and carbon taxation, come into force. Thus incentives will be created for private green investment. Public policies will also create incentives for private investors to finance research and development for green innovation to reduce emissions in the infrastructure sector, as new markets for green products and processes develop across the globe. In the developing world, private finance for mitigation will be bolstered by funds made available from the expanding CDM and other offsetting mechanisms.

Yet certain types of mitigation activity will require funding from public sources. In many developing countries, a proportion of major emissions-producing infrastructure assets - such as power and industrial plants - is owned by governments and almost all transportation infrastructure is publicly owned. Investment in reducing emissions from these sources will need to be obtained from public budgets. Indeed, although it is projected that the majority of the investment needed to move countries onto low carbon growth paths will come from the private sector, it is governments that “largely control the underlying infrastructure investments that affect the opportunities for energy-

efficient products” (World Bank, 2010a, p.261).

In general, raising private finance for infrastructure in the developing world has proven difficult, particularly in countries with more challenging investment climates³⁰ (see Box 7). Increased risk mitigation from public sources in the form of guarantees, grants and loans could help to encourage private climate change infrastructure investment in countries with challenging investment climates.

In contrast, adaptation funding is expected to be sourced largely from public budgets, with an emphasis on official flows including aid, levies on carbon market transactions, and emissions taxation. A large proportion of adaptation infrastructure costs will be devoted to climate-proofing public infrastructure, such as urban infrastructure and roads. This can be funded either by taxpayers (domestic or foreign), or from higher user-tariffs (World Bank, 2010a), although the latter approach raises concerns over excluding those unable to pay. There is also limited scope for private investment in dedicated adaptation infrastructure, such as flood defences and the protection of coastal zones, as it does not create commercial revenue (World Bank, 2010c).

But private funding sources will also play a role in adaptation. The costs of adapting privately-owned infrastructure, such as homes and businesses, will be met mainly by individuals through insurance and investments in climate-proofing

(World Bank, 2010a). The most vulnerable individuals and owners of small businesses in the developing world will find it difficult or impossible to source these extra funds however and there is a strong case for official flows to support this investment.

Public policy can make an important contribution in scaling up private investment in adaptation. The World Bank suggests three areas in which governments can try to involve the private sector: encouraging private sector actors to adapt autonomously; sharing the costs of adapting public infrastructure; and leveraging private finance to fund dedicated adaptation investments (World Bank, 2010c). Achieving these objectives would require a coherent policy framework, and associated capacity and resources.

³⁰ The difficulty of raising private finance for infrastructure in countries with difficult investment climates is illustrated by the current distribution of CDM finance, as discussed in section 4.

Box 7: Infrastructure financing in the developing world

It is estimated that 80% of infrastructure³¹ investment in the developing world in the past 15 years has been from public sources (Estache & Fay, 2007). Funding infrastructure puts a burden on already overstretched government budgets and in many developing countries infrastructure is undersupplied, creating bottlenecks to economic growth and barriers to meeting social development objectives. By way of example, a recent study of infrastructure needs in sub-Saharan Africa finds that there is an infrastructure funding gap of \$31 billion per year, even if major potential efficiency gains are realised (Foster & Briceño-Garmendia, 2010). These

figures put in sharp relief the challenges governments will face in finding additional funding for climate change infrastructure investments.

Donor funding provides support in some regions, but falls far short of meeting needs. Increased private sector involvement in the infrastructure sector is seen by many as desirable and necessary to help meet the funding shortfall and improve efficiency (although private sector involvement has been a source of controversy in cases where the cost of basic services increases).

Private investors are discouraged by high levels of risk in developing country

investment climates, including political instability, exchange rate risk, and risks related to the regulatory framework. Understanding and sharing these risks could serve to encourage private investment. Risks can be shared with governments or donors, using mechanisms such as guarantees, grants and concessional loans (OECD, 2006). But many risks are a result of weak institutions; reducing them sustainably is a long-term process. For the foreseeable future, the majority of infrastructure funding is likely to continue to be sourced from public funds, so improved government capacity to manage infrastructure investment remains a priority (Estache, 2006).

³¹ The definition of infrastructure used here is the narrower version referring to economic infrastructure: usually transport, energy, information and communication technology, irrigation, drinking water and sanitation.

Section 4: Summary of key points

- According to recent estimates, hundreds of billions of dollars annually are required for mitigation needs associated with the infrastructure sector in the developing world between now and 2030 (McKinsey and Company, 2009), and (very) approximately \$75 billion annually for adaptation needs in the infrastructure sector from 2010-2050 (World Bank, 2010c).
- Given the global distribution of responsibility for emissions, and the distribution of wealth, there is a powerful argument for the vast majority of this funding to be supplied through transfers from developed countries. In any case it is far beyond the capacity of most developing countries to raise funding on the scale required.
- Finance for climate-related infrastructure investment in the developing world is currently being made available through donor funding and carbon markets, but is inadequate by a large margin. Delaying action will only increase costs (Stern, 2006), so new and innovative strategies are urgently needed to increase the volume of funding.
- The CDM is widely expected to expand significantly in the coming decades, but many argue that it is in urgent need of reform. At present, the distribution of CDM finance is limited to narrow range of countries with relatively strong investment environments, and the Mechanism is directing little funding to certain key sectors such as transport and the built environment. One proposed approach to reform is 'sectoral CDM' in which emissions reductions would be rewarded across sectors rather than for projects. Proponents argue that this would improve the sectoral allocation of funding and create the right incentives for sector-wide transformations.
- Donor funding provides a vital source of support in the poorest countries which have limited resources and struggle to attract private investment, and also facilitates activities such as capacity-building, technology transfer, and risk mitigation which play an essential 'leveraging' role in making the transition to a climate-friendly and resilient world, and have no obvious alternative source of finance. Donor funding to date is limited and urgently needs to be scaled up. It will be important to make the best use of the limited funds available by exploiting synergies with existing financial flows - including existing aid transfers - and to ensure that donor contributions are well coordinated across sectors, countries and regions.
- International financial transfers will need to be combined with national policies in developing countries to encourage climate-friendly and resilient domestic investment. These include pricing carbon, regulating for energy efficiency, and revised zone planning and building codes that take into account new climatic conditions.
- There is far greater scope to leverage private finance for mitigation than adaptation in the infrastructure sector. Most emission-producing infrastructure is privately owned, whereas a great deal of the infrastructure that needs to be climate-proofed is publicly owned. Further, there is limited scope for private investment in dedicated adaptation infrastructure as it does not create commercial revenue (World Bank, 2010c).
- Increased risk mitigation from public sources (including donors) in the form of guarantees, grants and loans could help to encourage private climate change infrastructure investment in countries with challenging investment climates.

5. Key Challenge 2: Technology

The development of technologies, both for mitigating GHG emissions in the infrastructure sector as well as for adapting to climate change impacts, are of key importance to avoid irreversible changes associated with dangerous levels of climate change (UNFCCC, UNDP, 2009). For mitigation, technological advances are an essential ingredient in technological 'leapfrogging', and thus the realisation of low-carbon growth paths. Although less fundamental for adaptation, technology still has an important role to play in the development of infrastructure that protects communities from climate change impacts. Technological development has two components: the diffusion and scaling-up of existing technologies, and the development and deployment of breakthrough technologies (UN-DESA, 2009f).

Section 5.1 briefly discusses the new technologies that will be required to cope with climate change and how they will be developed, starting with mitigation and moving on to adaptation. Section 5.2 discusses technology transfer, first considering the complexity of the process and the mechanisms through which it currently occurs, and going on to explore strategies for accelerating and scaling up technology transfer.

5.1. Technological development

Technological progress is at the heart of meeting the challenge of mitigation in the infrastructure sector, and will play a key role in reducing the carbon constraint on growth. Critical technologies include: renewable energy; end-use energy reduction and efficiency technology in industry, transport, buildings and other infrastructure; and carbon capture and storage

(UN-DESA, 2009g, p.vii). Incentives for investment in developing new (or advancing existing) low-carbon technologies will be generated by international and national emissions limitations and, increasingly, carbon taxation, which will create markets for low-emissions technologies. It seems probable that much of the new innovation needed will take place in developed countries that have the capacity and financial resources to undertake advanced research and development. But some of the larger developing economies, particularly China, India and Brazil, are also playing an important role in innovation, and capturing a share of global markets for green technologies (discussed further in section 7.1). However, some low-carbon technologies are specific to developing countries, for example low-cost decentralised renewable energy for sub-Saharan Africa. For these technologies more localised development strategies will be required.

The development and dissemination of adaptation technologies requires a different approach. Most technologies appropriate to achieving adaptation objectives are also appropriate to meeting sustainable development objectives (UNFCCC, UNDP, 2009), for example low-cost irrigation for small-scale agriculture. It follows that technologies required for adaptation are context-specific to a greater degree than those required for mitigation, so richer countries cannot be relied upon to take a leading role in their development. The development of these technologies will require funding sources and capacity-building activities tailored to specific developing country needs. While

technology transfer still has a role, South-South technology transfer may be more important than North-South technology transfer in disseminating appropriate adaptation technologies. Indigenous technologies should be considered as far as possible since these would be more effective as tried and true coping mechanisms (UNFCCC, 2006).

5.2. Technology transfer

Many of the technologies required to delink emissions from economic growth are similar across the globe. For these technologies, technology transfer, and particularly transfer from richer to poorer countries, is crucial to enable the shift to low-carbon economies within the timescale required (UN-DESA, 2009g).

At present, technology transfer occurs principally through private sector foreign direct investment (FDI), embodied technologies in imported goods and services, and licensing (UN-DESA, 2009g). In middle-income countries, green foreign direct investment (FDI) stimulated by carbon markets and offsetting mechanisms such as the CDM will help to scale this up. However, the CDM will fall short of promoting technology transfer on the scale required for a number of reasons: low-income countries receive little investment from the CDM; most CDM projects are likely to be based on the diffusion of relatively mature technologies, rather than the deployment of new and innovative technologies (IEA, 2005); and the CDM may not be a good instrument to promote cumulative technological learning as it funds one-off projects rather than sectoral initiatives (UN-DESA, 2009g). Policies and arrangements beyond the CDM will therefore be

necessary to achieve the required scale of technology transfer. Initiatives required at international level include international and regional organisations to promote technology transfer, international financial transfers, and possibly changes to international intellectual property laws.

However, technology transfer is a far more complex process than a simple transfer of information, and efforts to promote the dissemination of technologies will be more successful if they are combined with initiatives (on the part of both donors and partner countries) to enhance absorptive capacities in developing countries (World Bank, 2010a). The IPCC definition of technology transfer captures its complexity:

“the process of learning to understand, utilize and replicate the technology, including the capacity to choose it and adapt it to local conditions and integrate it with indigenous technologies” (Halsnæs et al., 2007, p.158). Constraints faced by developing countries include low levels of technical expertise, weak legal frameworks to protect intellectual property rights, and the absence of institutions able to promote and coordinate technology transfer. Donors can provide important support by providing financial and technical assistance, but the development of enhanced absorptive capacity will depend critically on the strategies adopted by governments. A review of the evidence on technology leapfrogging finds that “[a] common feature of successful leapfrogging is a coherent set of public interventions in support of a long-term leapfrogging strategy” (Sauter & Watson, 2008, p.27). In common with other capacity-building needs, interventions aimed at enhancing technological absorptive capacity

are highly context-specific³², and each country will require its own needs assessment (see Box 8) but in general “a mix of generic functional policies (e.g. to strengthen levels of education) and more specific policies (e.g. to stimulate innovation in a particular sector) are required” (Sauter & Watson, 2008, p.summary). Again, perspectives, priorities and capacity vary greatly between countries depending on their stage of economic development amongst other factors. For the poorest countries, foreign aid (overseas development assistance – ODA) remains critical to support the development of basic capacities to acquire, adapt and use foreign technologies (Halsnæs et al., 2007).

As the above discussion makes clear, the active support of the developed world will play a key role in achieving technology transfer on the scale required. The World Bank (2010a, p.303) proposes that “[m]ultilateral funding can support technology transfer in three ways: by subsidizing investments in homegrown or foreign technologies in developing countries; by subsidizing the involvement of developing countries in...knowledge exchange, coordination, and cost-sharing agreements...; and by supporting national knowledge infrastructures and private sectors”. Developing country participants in global negotiations have argued that reforms to international agreements on intellectual property rights are also necessary; for example the right to exclude critical sectors from patenting (IPCC, 2004; UN-DESA, 2009g). Some existing and proposed

approaches to scaling-up technology transfer for GHG emissions reductions are described in Box 9.

³² For a table of ‘Key national policy priorities for innovation’ for different country income brackets, see World Bank, 2010a, p.303.

Box 8: Technology Needs Assessments

Funding and technical support is available from the GEF for countries to carry out 'Technology Needs Assessments' (TNAs). The purpose of TNAs is to "identify, evaluate, and prioritize technological means for achieving sustainable development in developing countries, increasing resilience to climate change, and

avoiding dangerous anthropogenic climate change" (UNFCCC, UNDP, 2009, p.5). Sixty-nine developing countries have submitted TNAs to the UNFCCC, many of which incorporate capacity-building needs related to technology. Uganda's TNA, for example, identifies the need for: "sensitisation of the public on many issues of climate change and

technologies, development of local expertise in developing local mitigation technologies and training private sector institutions on the process of identification, sourcing and deployment of mitigation technologies" (Technology Consults Ltd., 2006).

Box 9: Technology transfer: existing and proposed mechanisms³³

The **Clean Technology Fund (CTF)** is one of two Climate Investment Funds operated by the multilateral and regional development banks. It aims to increase public investment, and leverage private investment, for demonstration, deployment and transfer of low carbon technologies in the developing world. Current pledges to the CTF stand at US\$4.4 billion (Climate Funds Update, 2010).

The G77 - the largest intergovernmental organization of developing states in the

United Nations - is lobbying for the creation of **Multilateral Technology Acquisition Fund (MTAF)**, to facilitate global technology transfer and innovation under the rubric of the UNFCCC. This has so far proved to be a sticking point in negotiations, with some major developed nation parties arguing instead for voluntary agreements (Ellis et al., 2010).

The creation of **regional technology innovation centres** has been proposed by several countries during global

climate negotiations. The centres would be funded by both public and private sources. They would develop technologies shaped by regional or local needs, for example low-cost, decentralised renewable energy for Sub-Saharan Africa. They would also serve to pool resources and create economies of scale – essential for countries with small economies such as LDCs and SIDSs (UN-DESA, 2009b).

Section 5: Summary of key points

- Technological progress plays a crucial role in reducing the carbon constraint on growth, and also has an important part to play in protecting communities from the impacts of climate change.

Many of the technologies required to achieve low-carbon growth are similar across the globe, and it seems likely that richer countries will take a lead in developing these technologies. Technology transfer from the global North to the global South is therefore crucial to enable the shift to low-carbon economies within the timescale required.
- The active support of donors and international organisations will play

a key role in achieving technological progress and technology transfer on the scale, and within the timescale, required. Initiatives required at international level include international and regional organisations to promote technology transfer, international financial transfers, and possibly changes to international intellectual property laws.

- However, many developing countries are limited in their capacity to absorb technology transfer. Key constraints include low levels of technical expertise, weak legal frameworks to protect intellectual property rights, and the absence of institutions able to

promote and coordinate technology transfer. Efforts to promote the dissemination of technologies will stand a far higher chance of success if they are combined with initiatives (on the part of donors and developing country governments) to enhance absorptive capacities.

- Some low-carbon technologies (such as low-cost, decentralised renewable energy for sub-Saharan Africa), and many adaptation technologies (such as small-scale irrigation), need to be tailored specifically to developing country contexts. For these technologies more localised development strategies will be required, such as regional innovation centres.

³³ For a comprehensive list of proposed mechanisms, refer UN-DESA, 2009g.

6. Key Challenge 3: Capacity

The scale and urgency of the climate change challenge demands an ambitious response, yet developing countries can only take actions that are consistent with their capacity level³⁴ (Willems & Baumert, 2003). Insufficient capacity to formulate and implement climate change policy emerges consistently in the literature as one of the greatest challenges facing the developing world. National governments, already grappling with a multitude of developmental challenges, must seek to guide their economies onto a low-carbon growth path while maintaining economic growth, and prepare their populations and the private sector for climate change impacts that are difficult to predict.

Institutional weaknesses, poor access to information and modelling, low levels of human capacity, and inadequate financial resources make this difficult to achieve. Indeed, most rich countries are far from having developed a set of policy instruments that is adequate to meet the challenge. Development of climate change policy may also be hindered by “complex and context-specific social, economic, and political factors normally called institutions—the formal and informal rules affecting policy design, implementation, and outcomes” (World Bank, 2010a, p.321). Values, norms, organisational arrangements and patterns of individual or organisational behaviour suffer from

‘inertia’ and are slow to adjust in the face of new challenges (*ibid*).

Action in the infrastructure sector is particularly urgent for reasons described in previous sections of this report, but the task is complicated in many countries by existing capacity barriers and institutional challenges in key institutions responsible for infrastructure development. For example, a recent overview of the infrastructure sector in Africa identifies key capacity constraints in line ministries, independent regulators and state-owned enterprises (World Bank, 2010b). Greater involvement of, and provision of funding by, the private sector is constrained by weaknesses in the business environment, including poor access to finance and political and exchange-rate risk. The situation demands that policymakers add the complex problems associated with climate change to the existing challenges they face in developing infrastructure services that promote economic growth and meet the needs of the poor.

Countries’ ability to successfully develop climate policy, and mainstream mitigation and adaptation objectives routinely into policy decisions across a broad spectrum, will depend to a significant extent on their institutional structures and whether they are able to develop a coherent climate change policy framework, as discussed below.

Capacity-building needs related to climate change in the infrastructure sector are present at all levels of government, in the construction industry and in civil society and communities; examples are given throughout this report. But overall responsibility for leading climate change policy rests with national

governments. A range of key roles that only government can fulfil are discussed below; indeed, one of governments’ responsibilities is designing and implementing a capacity-building programme that covers industry, communities and civil society, as well as regional and local government bodies.

Accordingly, rather than discussing a range of specific capacity-building needs and how these will be met, section 6.1 takes a broad focus on how governments will cope with climate change in the infrastructure sector. This is based on the understanding that, if governments are capable of developing and implementing climate change policy across sectors and scales, capacity-building needs in general are far more likely to be met, and the country in question is more likely to be able to cope with the negative impacts of climate change and emissions-reductions obligations, and profit from the potential opportunities discussed in sections 7 and 8.

Section 6.2 discusses the role of high-income countries in supporting capacity-building.

6.1. Capacity for policy development within national governments

Prime responsibility for developing mitigation and adaptation policy in the infrastructure sector rests with national governments. Emissions reductions depend on governments introducing policy and regulations that influence markets, as climate change has been caused by multiple market failures; the failure to internalise the costs associated with GHG emissions, market failures in research and technology development, and failures of collective action at global, local and

³⁴ Capacity can be defined here as: “the ability of individuals, institutions and societies to perform functions, solve problems, and set and achieve objectives in a sustainable manner” (UNDP 2007, p.5).

national levels (World Bank, 2010a). Governments will be required to create the framework that defines the roles and responsibilities of the public sector, private sector, households and individuals in mitigating and adapting to climate change (World Bank, 2010a). And it will be the responsibility of governments to play an ‘ensuring’ role, guaranteeing that “targets and goals are achieved through new emphasis on regulation, taxation, long-term planning and communication” (World Bank, 2010a, p.331). Responsibility for generating and disseminating projections of climate change impacts will also fall principally to governments. Yet the responsibilities of government in the sphere of infrastructure and climate change do not end here as funding sources for infrastructure in the developing world remain largely public (see Box 7). So it will also be predominantly public bodies that will be charged with taking the investment decisions needed to develop an infrastructure sector that generates developmental outcomes in a carbon constrained, warming world.

Developing country governments will also have more money to manage; mitigation and adaptation will both increase public spending in the infrastructure sector in the developing world, since governments will have extra funds at their disposal from international transfers agreed in climate negotiations (World Bank, 2010a). International financial transfers are clearly necessary, but the absorptive capacity of governments is limited. Particularly in the case of adaptation funding, many of the countries most in need of funding transfers to cope with climate change impacts are those with least capacity to manage

and absorb funding (World Bank, 2010a). Again, this is particularly pertinent in the infrastructure sector. A renewed recognition of the importance of infrastructure to developmental goals in recent years has led to calls for increased donor funding for infrastructure development in the poorest countries, but this is tempered by concerns over the “managerial ability of the public sector administrations of many countries to deliver significantly higher levels of service at equal or improved levels of service quality” and the risk that a “dramatic scale-up in aid risks overwhelming fragile institutions” (Estache, 2006a, p.9).

Governments are pivotal in meeting the challenge of climate change in the infrastructure sector at national level, but how they should approach the task of policy development? Each country’s approach will be unique, but there is broad consensus that the foundation for successful policy development - and successful management of climate-related funding - is the development of an ‘overall policy framework’, that would facilitate integrated planning across sectors (i.e. across various infrastructure sectors, as well as forestry, health, coastal management, etc.) and scales (i.e. national, provincial, and local governments) (GEF & UNDP, 2000; Zakri et al., 2000; Mugabe et al., 2000; GEF, 2003). Such a policy framework would enable mainstreaming of climate change into national development paths. It is difficult to imagine that this could be achieved any other way. It would also support the complex process of optimising the use of limited resources by establishing priority sectors and actions for both mitigation and adaptation, assigning resource use between mitigation

and adaptation, and evaluating potential synergies with development. The World Bank states the problem thus:

Policy coherence throughout an administration requires integrating climate planning across government. Here, the challenge is the typical compartmentalization of government work and the tendency to treat multidimensional problems in organizational silos. Approaches for integration include establishing climate units in each ministry or agency complemented by sectoral plans at national and local levels for mitigation and adaptation. In addition to a revision of their mandates, relevant public agencies—such as those involved in public health, energy, forestry and land-use planning, and natural resource management—can coordinate their work under a lead climate-change agency. For both integration and coordination, particular attention should go to developing sector policies and strategies. (World Bank, 2010a, p.333)

The characteristics of such a framework would be highly context-dependent, but the challenges in creating them are clear. In the case of Asia and the Pacific:

Specific capacity development interventions needed to address the lack of overall national climate policy framework revolve mainly around clearly defining the mandates of various agencies engaged in climate change, strengthening climate change focal points “or national authorities designated to coordinate climate change activities,” instituting mechanisms of accountability to the public, and raising the level of public awareness of the issue. (Zakri et al., 2000, p.33)

As this quotation suggests, capacity-building strategies for climate change in the infrastructure sector at national level will need to be based on an understanding of which agencies are the most appropriate to take a leading role in climate change infrastructure policy, and their existing capacity and institutional structures. For example, important government bodies for mitigation will include those with responsibility for energy, transportation, and industry. For adaptation, agencies with responsibility for water, urban development, agricultural infrastructure and coastal zones will play a more important role.

The challenges associated with the process of developing and implementing a policy framework for climate change in the infrastructure sector should not be underestimated. Such frameworks are an aspiration for most developmental processes, but have proven consistently difficult to develop due to barriers such as inadequate skills and personnel, lack of coordination, vested interests, lack of political will, weak civil society, and institutional inertia. In reality policy development tends to be fragmented in nature, and its outcomes depend on the level of influence of different groups in society, including various political groupings, the private sector, NGOs and scientific experts (Sathaye et al, 2007).

Infrastructure development policy frameworks provide a prime example and in fact share some of the key complexities of climate change policy development, such as coordinating fragmented groups, carrying out complex risk assessments, and planning for a long time horizon. A recent UNDP report examining the links between

infrastructure and poverty (UNDP, 2005) finds that “the frailty of institutions essential to the pooling of resources [i.e. able to generate agreement amongst fragmented groups on collectively desired levels of production of social or public goods] usually results in failure to provide major infrastructure projects, such as interconnected power grids, transportation hubs and networks, and complex irrigation projects” (UNDP, 2005, p.21). Successful development and implementation of climate change policy will require precisely this “agreement among fragmented groups”, and there is clearly a danger that “the multi-faceted, multi-sectoral nature of the issue of climate change [will lend] itself...to confusion or fragmentation of institutional mandates and responsibilities” (Zakri et al. 2000, p.36). Integrating climate change considerations into an infrastructure sector which is currently inadequate and fragmented in many developing countries is a daunting task.

The fragmentation of the infrastructure sector has complex and context-dependent causes. The sector has multiple stakeholders, some of whom have powerful political and financial interests in maintaining the status quo, making institutional change difficult to realise. For example, resistance to changes in energy production will be strong in countries with large fossil-fuel based energy sectors (World Bank, 2010a). Changes in public procurement rules can also be difficult to realise in cases where the existing system generates opportunities for illicit gain amongst powerful stakeholders. Each country has its own unique ‘political economy’ of the infrastructure sector; efforts at capacity building stand a far greater chance of success

if they are designed with an understanding of these dynamics.

A further obstacle is presented by the high proportion of construction activities that take place in the informal sector in developing countries. The informal sector is difficult to reach through capacity-building initiatives and, where reforms are successfully passed, the associated laws and regulations will prove challenging to enforce.

6.2. The role of high-income countries in supporting capacity building

Support from high-income countries is critical in building capacity across sectors and scales, principally in the form of funding and technical assistance. Private finance will not be available for capacity building, so governments will need to source funds from their own budgets or foreign aid. Donors are well positioned to work through existing channels of development assistance to build capacity for integrating climate change into developmental decisions in the relevant institutions (Ayers & Huq, 2008).

Each country has a unique profile of capacity-building needs dependent on factors including economic structure, stage of development and exposure to climatic impacts. So the identification and prioritisation of needs is the first requirement for a national programme of climate change capacity building. Donor support is critical in enabling many countries to carry out capacity-building needs assessments but, in common with other development projects, it is of paramount importance that projects are demand-led (i.e. that needs and priorities are identified by the partner country, not the donor) to the greatest extent possible (Zakri et al., 2000). Capacity-building needs

assessments are already underway in many countries, often supported by multilateral funding via the GEF.

The process of capacity-building is complex and context-dependent, and the concept of best practice is constantly evolving:

Approaches to capacity development have evolved over the past decades from a more institutions-specific, skills-enhancement and training-based approach into one that takes into consideration both the overall system within which institutions and individuals interact and operate and the institutions and individuals themselves as critical components of a comprehensive approach to capacity development. (GEF & UNDP, 2000, p.60)

As earlier sections of this report make clear, action on climate change is urgent, whereas the above quotation and the previous section make clear that capacity-building is complex, context-dependent and requires a long time commitment. Thus a fundamental conflict of interests in international development is amplified in the case of climate change: should urgent developmental needs be met using a 'project approach' relying on foreign technical and management expertise

and financing, or is it better to promote a gradual (and more sustainable) approach focused on building the requisite capacity in the partner country? There is divergence amongst developing country parties to the UNFCCC on which of these approaches is preferable (GEF & UNDP, 2000). In fact there is no clear-cut dichotomy between the two as governments need not have all the required capacity in place before taking steps to combat climate change. In some circumstances, adopting a commitment - either domestic or international - may act as a driver for capacity building (Willems & Baumert, 2003). One proposed model for the evolution of climate actions is "a step by step approach, whereby countries in each step assess their existing capacities and select future actions that are consistent with the capacity level it can reasonably reach within a given time frame" (Willems & Baumert, 2003, p.5). In reality, a combination of 'project' approaches and more country-owned approaches is likely to be required to meet the challenges within the required time-frame, with an overall objective of improved country capacity in the long term.

The challenges presented by capacity constraints are daunting, but capacity-building initiatives can also provide important opportunities for the developing world. The need for capacity-building to meet the challenge of climate change is well understood and capacity-building programmes funded by multinational organisations are already underway in many countries (although they remain under-resourced, as discussed in section 4). Capacity, and particularly the capacity of national governments, is at the heart of many developmental challenges, not least the challenge of providing adequate infrastructure services. As discussed earlier in this section, capacity challenges in infrastructure and climate change policy share some key characteristics. The learning processes associated with climate change, and the resources dedicated to capacity-building in the many infrastructure sectors that have a role to play in mitigation and adaptation, may generate positive spillover effects in the infrastructure sector as a whole.

Section 6: Summary of key points

- The extent to which countries will be able to meet the challenge of climate change will depend to a large degree on their ability to develop a coherent climate change policy framework. Such a framework would: integrate climate change objectives with national plans and budgetary frameworks; facilitate integrated climate change planning across sectors and scales; and support the mainstreaming of mitigation and adaptation objectives routinely into policy decisions across a broad spectrum.
- This is difficult to achieve in many developing countries due to institutional weaknesses, poor access to information and modelling, low levels of human capacity, and inadequate financial resources. Climate change policy development is uniquely challenging because the issue spans across multiple sectors and scales, and so requires extensive coordination between government agencies that normally work in silos. In the infrastructure sector, the challenges are exacerbated by existing capacity constraints and institutional barriers in key institutions responsible for infrastructure development.
- Building the capacity of developing country governments to formulate and implement climate change policy will therefore form an important part of programmes to support developing countries in meeting the challenge of climate change.
- Support from high-income countries is critical in building capacity. Donors are well positioned to work through existing channels of development assistance to build capacity for integrating climate change into developmental decisions in the relevant institutions.
- However, the process of capacity-building is complex, context-dependent and requires a long time horizon. In the short-term, at least for countries with lower capacity, a combination of ‘project approach’ interventions relying on foreign technical and management expertise and more gradual interventions focused on building the requisite capacity in the partner country is likely to be required to meet needs within the timescale required. One proposed model for achieving this is “a step by step approach, whereby countries in each step assess their existing capacities and select future actions that are consistent with the capacity level it can reasonably reach within a given time frame” (Willems & Baumert, 2003, p.5).
- Capacity-building strategies for climate change in the infrastructure sector will need to be based on an understanding of which agencies are the most appropriate to take a leading role in climate change infrastructure policy, and their existing capacity and institutional characteristics.

7. Maximising the Developmental Outcomes of Mitigation in the Infrastructure Sector

The consequences of climate change are often seen as overwhelmingly negative for developing countries, but developmental opportunities are also created by international and national policies for mitigation and adaptation. Taking advantage of these opportunities can help to counteract the negative economic and social impacts that result from climate change impacts.

Opportunities associated with mitigation can also offset the potential dampening effect on growth that many developing countries fear will result from reducing emissions. Countries' ability to harness these opportunities depends on multiple contextual factors, including their stage of economic development and capacity to develop and implement appropriate policies.

This section discusses potential developmental opportunities arising from global and national mitigation strategies and briefly considers the actions required to realise them. Section 7.1 discusses some key opportunities arising from international policy to reduce emissions. Section 7.2 explores in detail the topic of green jobs in the infrastructure sector, which holds particular significance for the construction industry and poverty reduction. Section 7.3 discusses synergies between national mitigation strategies and developmental priorities, for example renewable decentralised energy in rural areas. Section 7.4 discusses the potential advantages of regional cooperation.

7.1. Opportunities arising from international mitigation policy: finance, technology and new markets

International efforts at reducing emissions are generating some potentially important economic opportunities for developing countries. Generally, the opportunities described below are more accessible to middle-income countries than low-income countries. The reasons for this are discussed in greater detail later in this section.

Perhaps the most significant opportunity is access to new sources of finance from the 'international mitigation pot', as many of the most cost effective mitigation opportunities are in the developing world. A recent study finds that a globally efficient distribution of mitigation investment would see 67% of total investment being made in developing countries (McKinsey & Company, 2009). Market mechanisms such as the CDM have been established specifically to facilitate a transfer of mitigation funding from the developed to the developing world. Some developing countries will be able to capitalise on this to finance green infrastructure development, thus generating developmental outcomes that go far beyond mitigation (Ellis et al., 2010).

Funding for mitigation in the developing world will not be sufficient to stimulate a shift to low-carbon growth without a corresponding increase in rates of international technology transfer (see section 5). New institutions and financing designed to encourage technology transfer for mitigation may provide opportunities for developing countries to acquire expertise in emerging technologies as a basis for building competitive industries (UN-DESA, 2009g). In a related point, mitigation will create

new international markets for environmental goods and services, which some developing countries will be able to capitalise upon (Ellis et al., 2010). For example, China and India are already leading producers of wind energy and wind energy manufacturing equipment, China is a major exporter of solar photovoltaic technologies, and Brazil is a world leader in bioethanol production and associated technologies (*ibid*). These countries' success is due in part to their economic and technological capacity, but is also a result of their governments' proactive stance. Incentives have been created within the private sector for investing in research and development for new technologies, and developing and disseminating existing technologies, using public policy tools including funding for research and development (R&D), providing finance on good terms, and providing tax breaks. China's strategy, which incorporates many of these elements, is described in Box 10.

Box 10: Case study: China's renewable energy strategy

China's Renewable Energy Law, passed in 2005, offers a variety of financial incentives, such as a national fund to foster renewable energy development, discounted lending and tax preferences for renewable energy projects, and a requirement that power grid operators purchase resources from registered renewable energy producers. The additional generating capacity from

wind power has exhibited an annual growth rate of more than 100% from 2005 to 2009. China is the largest Solar PV manufacturer in the world, and produced 45% of global solar PV in 2009. The domestic solar market has started developing more recently, with about 160 MW solar PV installed and connected to grid in 2009. But with more than 12GW of large projects in the

pipeline, it could rapidly become a major market in Asia and the world. China is now the world's largest market for solar hot water, with nearly two-thirds of global capacity.

Source: UNEP Green Economy Success Stories:

<http://www.unep.org/greeneconomy/SuccessStories/RenewableEnergyinChina/tabid/29865/Default.aspx>

Green technological change as a result of additional finance, technology transfer and / or production for new green markets is likely to stimulate industrial progress, which plays an important role in economic growth (Ellis et al., 2010). Industrial progress related to environmental policy generates particularly important opportunities in sectors far below their 'production frontier' – i.e. where production is far below the maximum feasible with the same amount of inputs – a situation frequently encountered in the developing world. In these sectors there are opportunities for development win-win-wins, where green technological progress can free up resources and encourage growth, reduce GHG emissions, and meet other sustainable development goals (Sathaye et al, 2007). Countries in the process of transition to a low-carbon economy will also experience a transition in the labour market, which is projected to generate additional 'green' jobs in the infrastructure services sector, as discussed in detail in section 7.2 (UNEP, ILO, IOE, ITUC, 2008a).

Those countries that are able to take advantage of international investment flows and technology transfer to make the transition to a low-carbon economy will find

themselves in a better position for long-term sustainable growth as agreements on the limitation of global emissions increasingly come into force (Ellis et al., 2010).

Potential opportunities are summarised in Figure 4.

Harnessing these opportunities will require proactive policy development on the part of governments and is therefore directly related to governmental capacity (as discussed in section 6). Governments that are able to develop a coherent and clearly articulated national mitigation strategy will create a more attractive environment for green investment and thus obtain greater access to international public and private funding flows. Governments that clarify the future direction of policy and the key decisions that will be made, for example on energy sourcing and infrastructure development, will give business greater confidence to undertake the low carbon investments that are needed, in the knowledge that future policy development will be consistent with a positive return on their investment. Tools at governments' disposal include pricing carbon, environmental regulations, energy efficiency standards, and direct investment in R&D (Fisher et al., 2007).

Capacity to develop mitigation strategy varies widely between countries. A key constraint in the energy sector is limited capacity to analyse future trends in the price of carbon, and the future price of energy from various sources, and integrate the results into national infrastructure development plans (Chandler et al., 2002)³⁵. This is exacerbated by enormous uncertainty surrounding future carbon prices and the development of new renewable energy technologies, which reduce incentives to take difficult decisions early on. Many countries also have limited capacity to monitor and enforce emissions limitations, particularly at local government level (GEF & UNDP, 2000). A further set of constraints arise from poor collaboration and communication between governments and the private sector. Open channels of communication will be important to

³⁵ Concern over the paucity of information available to support decision-making were expressed by the (African) authors of the GEF/UNDP Capacity Development Initiative Regional Report for Africa: "Analytical tools for climate change such as models are virtually absent or not applied in African decision-making at national, sectoral and institutional levels." (Mugabe et al., 2000, p.47).

facilitate the prompt communication of changes in policy and thus enable firms to adjust their business plans to take advantage of opportunities arising from mitigation policies and

mitigate the corresponding risks. The weakness of the rapport is a cause for concern in many regions, including Africa where “public sector efforts to enlist greater private

sector participation in climate change management have received limited or poor response from industry” (Mugabe et al., 2000, p.50).

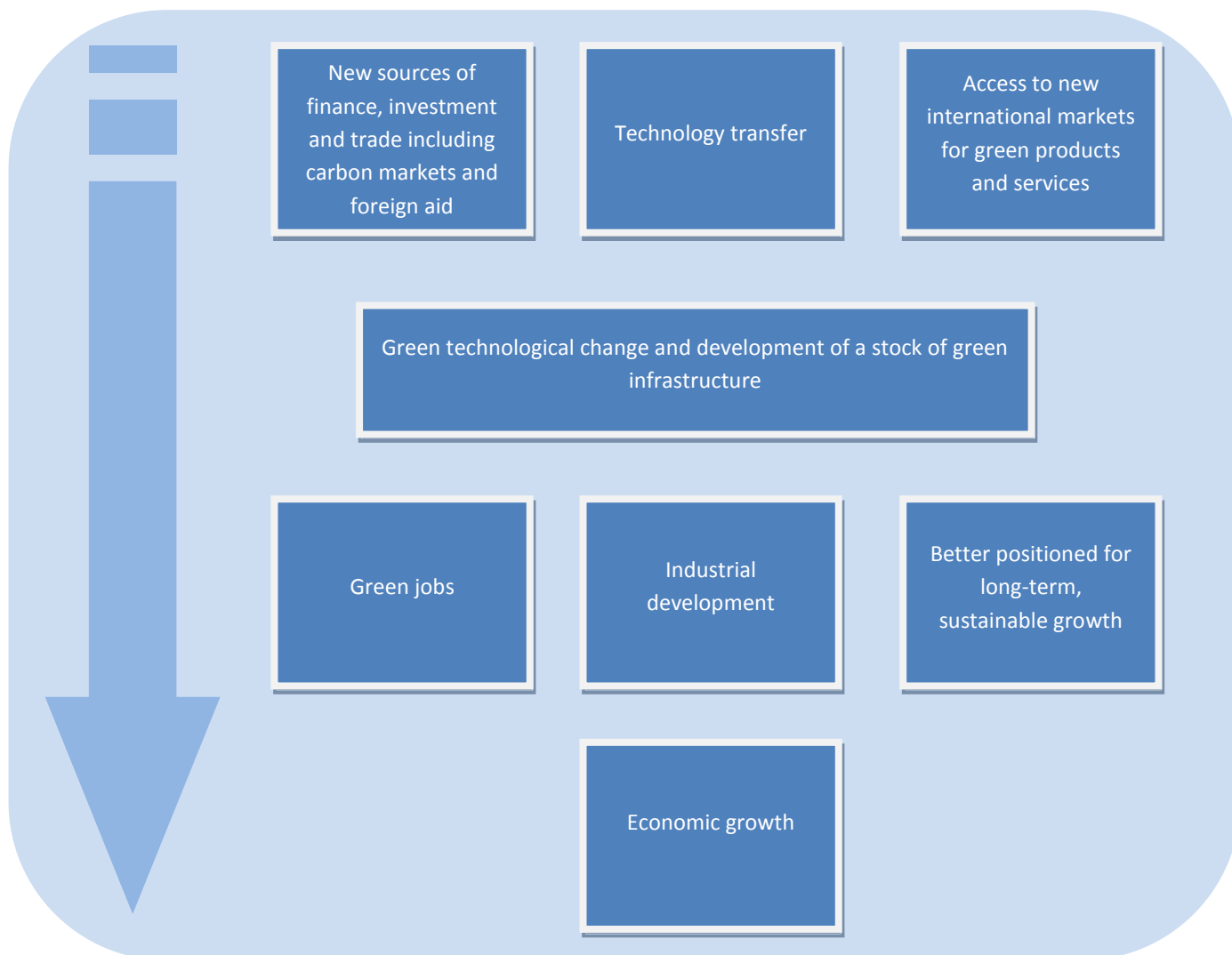


Figure 4: Potential opportunities arising from global mitigation efforts

Sources: Ellis et al., 2010; Sauter & Watson, 2008; UNEP, ILO, IOE, ITUC, 2008

Access to opportunities arising from global mitigation strategies is not equally distributed among income-brackets. Middle-income, more industrialised countries generally see these opportunities as more relevant to their economic development and are also better positioned to take advantage of them. In low income countries, economic activity tends to be based

on agriculture. Agricultural activity has low energy consumption so, unless these countries are growing rapidly, they are unlikely to present significant mitigation investment opportunities, and carbon markets are not yet sufficiently well developed to facilitate private funding of mitigation options in agriculture or forestry. In addition, the investment climates (i.e.

strength of institutions, the rule of law, the business climate, etc.) of low-income countries are generally higher risk, making it more difficult to attract foreign investment. Reduced green investment implies less exposure to new, low-carbon technologies, and thus lower rates of technology transfer. This is compounded by low-income countries’ reduced capacity to

absorb technology transfer, as discussed in section 5. Middle-income countries also have greater resources to invest in the initial risks of developing new products for low carbon markets. Finally, the new 'green jobs' created by a transition to a low-carbon economy are principally in the industrial sector so, again, industrialised countries are likely to obtain more benefits from this transition.

Although it may appear less pressing, developing low carbon growth strategies remains important for low-income countries to avoid becoming locked-in to high emissions paths. The African Development Bank summarises the potential opportunities thus: "[f]rom a relatively low base, Africa has the opportunity to pursue a low carbon intensive development pathway as sustainable growth requires access to diverse, reliable, affordable clean and renewable energy sources" (ADB, 2010). Further, although low-income countries may stand to gain less in terms of volume of funds from mitigation efforts, the investment and technology transfer opportunities that are open to them may be significant considering the small size of their economies, and the developmental synergies associated with many mitigation interventions (see section 7.3). As their economies grow, low-income countries may be able to learn lessons from the approaches taken by middle-income countries that are successfully harnessing the opportunities created by global mitigation strategies, and turn them to their economic advantage.

7.2. Green jobs³⁶

³⁶ This section draws upon the report "Green Jobs: Towards decent work in a sustainable, low carbon world" (UNEP, ILO, OIE, ITUC, 2008a). All references

The transition to a low carbon economy will engender a labour market transition. An important element of this will be the creation of new 'green jobs', defined as jobs which "contribute substantially to preserving or restoring environmental quality" (UNEP, ILO, IOE, ITUC, 2008b, p.3). The green jobs transition will impact all the sectors covered under mitigation in this report: energy, buildings, transportation, and construction materials. Job creation potential in each sector is briefly analysed below, followed by a discussion of the action required to successfully manage the transition.

In the energy sector, the greatest potential for green jobs lies in renewables, i.e. wind, solar, biomass geothermal and hydro. Compared to fossil-fuel power production, renewable energy creates more jobs per unit of power generated and per dollar invested. In recent years, 2.3 million renewable energy jobs have been created, half of which are in emerging or developing economies and this figure is predicted to increase to as much as 20 million by 2030. To date, these opportunities are concentrated in certain countries that have aggressively pursued renewable energy technological development: in 2006, OECD countries contributed 82% of renewable investment, and China and India a further 12%. China increased investment in the sector by more than 2000% between 2004 – 2008 and the Chinese renewables sector now employs 1 million people. In contrast to renewables, nuclear power and carbon capture and storage (CCS) are high-technology industries that create

are from this report, unless stated otherwise.

few jobs and very little unskilled employment³⁷.

The buildings sector has very high potential for green jobs creation, mainly in improving energy efficiency. No figures are available on the number of jobs that could be created but, when we consider that buildings is the infrastructure sector with the greatest potential for rapid and significant GHG emissions reductions (see sections 3.1 and 9.1.1), the scale of the work required to realise the transition and the fact that the construction industry currently employs 5-10% of the total global workforce (111 million people), the potential is clear. In addition, the majority of work to improve the energy efficiency of buildings will be in retrofitting, which creates jobs that would not otherwise have existed, as opposed to a 'transition' from one type of work to another (an example of such a project is given in Box 11). In some countries the potential for retrofitting employment is likely to be realised soon and on a large scale: in 2005, Chinese officials announced that the country will transform all existing buildings into energy-saving buildings by 2020.

The buildings sector holds unique potential for pro-poor green job creation in the developing world, for two reasons. Firstly, the construction sector is principally made up of small and medium enterprises (SMEs); 90% of global construction occurs in firms that have 10 or less employees. These firms tend to employ a high proportion of unskilled workers and recycle much of their profits back into the communities in which they work. Secondly, work to improve

³⁷ The 'Green Jobs' report does not classify jobs in nuclear power as 'green'.

the energy efficiency of buildings will almost always be carried out on site, so the benefits will accrue to local communities.

Box 11: Case Study: Green upgrading of low-income housing in South Africa

As part of the Kuyasa Low-Income Housing Upgrade in Cape Town, South Africa, local artisans and unemployed youngsters were trained to insulate the roof, install solar thermal water heating equipment, and replace incandescent light bulbs with energy efficient bulbs. With support from the NGO SouthSouthNorth, the scheme qualified for support from the CDM, and has now been scaled up to benefit some 2300 households. The scheme will provide long-term opportunities for employment, and for local small and micro-enterprises.

Source: UNEP, ILO, OIE, ITUC, 2008b, p.10

In the transportation sector, green jobs will be created in public transport as governments implement policy to move journeys from private to public vehicles. The railways sector is particularly labour-intensive – there are five million existing green jobs in railways across China, India and the EU - and is likely to come to play a more important role in freight transport as well as passenger transport. Skilled jobs will be created in the design and production of fuel efficient and green fuel vehicles. Overall more jobs are likely to be created than lost.

In the construction materials industry, three principal actions are required to reduce emissions: improve energy and materials efficiency; reduce pollution;

enhanced use of scrap for recycling. There is likely to be an overall reduction in the number of jobs available in industry, caused by a drive for greater efficiency and the use of more modern, less polluting equipment. However, jobs will be created in recycling. In China, an estimated 10 million jobs already exist in recycling across all sectors.

Green jobs are currently concentrated in certain countries and regions; in the developing world China, India and Brazil provide examples of what can be achieved. The UNEP, ILO, IOE, ITUC 'Green Jobs' report (2008a) proposes that a coherent policy framework and strong government leadership will be required to harness the employment benefits of the transition, and sets out the six steps in Box 12 for action.

Box 12: Green Jobs – an Agenda for Action

1. Assess the potential for green jobs and monitor progress.
2. Closing the skills gap: building the capacity of potential green workers.
3. Greening of workplaces.
4. Political resolve – stable policy frameworks, prices and incentives. Market signals have an important role to play, as does public policy in areas such as R&D and successfully dealing with the politics of the transition, particularly compensating the losers.
5. Scaling up investment: use national and foreign public investment to leverage private investment.
6. Financing green jobs: R&D, reallocation of perverse subsidies, eco-taxes and

auctioning of carbon credits, invest in small enterprises and communities, improve the CDM to make it accessible to more countries, communities and small enterprises.

7.3. Synergies between national mitigation strategies and national development priorities

The case for rapid and decisive action to reduce emissions is strengthened by the existence of development win-wins associated with low-carbon infrastructure choices. For example, in developing countries where a high proportion of the population still lack access to electricity, investment in decentralised forms of energy, such as solar or wind power (as opposed to fossil-fuel based centralised grids) could achieve both green growth and more inclusive growth. By way of illustration, a case study of a decentralised, renewable energy programme funded from international sources is provided in Box 13, while the anticipated developmental outcomes of the Kenyan government's policy to encourage renewable energy production are described in Box 14.

Similarly, developing mass transit systems in cities would slow growth in the use of personal vehicles and the associated emissions, while simultaneously providing poor urban dwellers with improved transport options and better air quality. In certain cases it may also be possible to identify synergies between mitigation and adaptation, for example a dam to prevent flooding and adapt to variability in runoff could also be used to produce hydropower (World Bank, 2009) (further examples of synergies are provided in Annex A). A recent

report from the Pew Centre on Global Climate Change illustrates how pervasive these synergies can be. It finds that the economies of Brazil, China, India, Mexico, South Africa and Turkey have reduced the growth of their combined annual GHG emissions over the past three decades by an estimated 300 million tons a year through development projects that do not have explicit emissions-reductions goals, but are driven by economic, security or local environmental concerns (Chandler et al, 2002).

Identifying and exploiting synergies between climate change infrastructure investment and development has important

advantages. Dedicating scarce resources to climate change investment is politically difficult in the developing world, where the impacts are often not yet manifest, responsibility for emissions reductions is (understandably) seen by many to lie with developed countries, and there are many competing urgent needs. As a consequence, developmental synergies can be seen as a way of enhancing the relevance and popularity of climate change investments (Davidson et al., 2003). In addition, experience has demonstrated that successful integration of environmental concerns into the political arena is

priorities are linked to other national priorities (GEF & UNDP, 2000).

Climate change infrastructure investment decisions should ideally be informed by a thorough analysis of potential mitigation-adaptation-development synergies, and their relationship with developmental paths, in order to generate the greatest economic, social and environmental value (Wilbanks & Sathaye, 2007). Achieving this would entail integrating climate change objectives with national plans and budgetary frameworks. Limited information, capacity and resources present barriers to achieving this type of integrated policy development in many developing countries

Box 13: Case study: Sri Lanka Rural Energy Programme

The Sri Lanka Rural Energy Programme, funded by grants from the World Bank (IDA) and the GEF, finances small-scale, renewable-based rural power projects. The projects are proposed by private enterprises and screened for economic

and technical viability by participating credit institutions. The Programme commenced in 1998, and has provided an off-grid connection to 136,839 households to date (March 2011), through solar home systems and

independent mini grids powered by village hydro, wind or biomass.

Sources: World Bank, 2006, p.40, Sri Lanka Energy Services, 2010

Box 14: Case study: Feed-in tariffs in Kenya

Kenya's energy profile is characterized by a predominance of traditional biomass energy to meet the energy needs of the rural households and a heavy dependence on imported petroleum for the modern economic sector needs. As a result, the country faces challenges related to unsustainable use of traditional forms of biomass and exposure to high and unstable oil import prices. In March 2008, Kenya's Ministry of Energy adopted a feed-in tariff, stating that "renewable energy sources including solar, wind, small hydros, biogas and municipal waste energy have potential for income and employment generation, over and above contributing

to the supply and diversification of electricity generation sources". The advantages of this policy include: a) environmental integrity including the reduction of greenhouse gas emissions; b) enhancing energy supply security, reducing the country's dependence on imported fuels; and coping with the global scarcity of fossil fuels and its attendant price volatility; and c) enhancing economic competitiveness and job creation.

As Kenya's greatest renewable energy potential is in rural areas, the effects of the feed-in tariff policy are expected to trickle down and stimulate rural

employment. This can happen through the construction of power plants, but also in the context of agro-industries, in particular sugarcane, which is predominant in the country. Since the announcement of the feed-in tariff policy, some sugar companies have planned to upgrade their biomass-based cogeneration potential in order to benefit from the FIT policy.

Source: UNEP Green Economy Success Stories: <http://www.unep.org/greenconomy/SuccessStories/FeedintariffsinKenya/tabid/29864/Default.aspx>

7.4. Regional cooperation

Improved capacity for regional cooperation would support mitigation in the infrastructure sector through several channels. Mitigation investment is currently constrained by the small market size of most low-income countries, which makes them unattractive to investors wishing to introduce new technologies. Regional markets can create a critical mass that attracts entrepreneurs (World Bank, 2010a). Regional cooperation would support the transition to a low carbon economy: in the transportation sector, by developing sizable markets for ethanol fuels and supporting the regeneration of regional public transport systems; in the energy sector by lowering the

cost of off-grid systems and connecting grids to share electricity resources; in the buildings sector by creating larger markets for low-energy or renewable systems (Davidson et al., 2003). Regional economic groupings are more likely to be able to attract foreign investors, and thus benefit from the associated technology transfer, while the absorption and dissemination of climate-friendly technologies could be supported by regional collaboration, as described in Box 9. The development of regional institutions could also play an important role in overcoming the barriers presented by energy security risks associated with shared power sources (Mugabe et al., 2003).

However, there are complex institutional, political and coordination barriers to enhanced regional cooperation, one of the most important being countries' reluctance to constrain national sovereignty by entering into regional agreements. An in-depth discussion of how these might be overcome is beyond the scope of this study, although it is clear that it will be important to build on existing regional ties and models of regional groupings (such as the Economic Community of West African States (ECOWAS) and the Association of Southeast Asian Nations (ASEAN)) in efforts to promote enhanced regional integration for mitigation.

Section 7: Summary of key points

- Opportunities for developing countries arising from *international* efforts at mitigation include: access to new sources of finance, since many of the most cost effective mitigation opportunities are in the developing world; accelerated rates of technology transfer; and access to new international markets for green products.
- Harnessing these opportunities will require proactive policy development on the part of governments, a key element of which would be a coherent and clearly articulated national mitigation strategy. Such a strategy would position the country to attract international funding, and give business the confidence to make low-carbon investments in the knowledge that future policy development will be consistent with a positive return on their investment.
- Countries in the process of transition to a low-carbon economy will also experience a transition in the labour market, which is projected to generate additional 'green' jobs in the infrastructure sector, particularly in renewable energy and the buildings sector. The buildings sector holds unique potential for pro-poor green job creation: firstly, because the construction sector is principally made up of SMEs that tend to employ a high proportion of unskilled workers and recycle much of their profits back into the communities in which they work; secondly, work to improve the energy efficiency of buildings will almost always be carried out on site, so at least some of the benefits will accrue to local communities. However, there is little data currently available on the number of jobs that could be created.
- Proactive policy development on the part of governments will also be required to harness opportunities associated with green jobs. Strategies include: building the capacity of green workers; policies to compensate the losers from the transition; and using funding associated with mitigation to finance green jobs.
- Many low-carbon investment options also contribute to national development objectives. Examples include decentralised renewable energy for rural areas and mass transit systems in cities. Identifying and exploiting these synergies can support efforts to achieve long-term developmental goals, as well as enhancing the relevance and popularity of climate change investments. Some investment options also have synergies with adaptation priorities. Climate change infrastructure investment decisions should ideally be informed by a thorough analysis of potential mitigation-adaptation-development synergies, and their relationship with developmental paths, in order to generate the greatest economic, social and environmental value (Wilbanks & Sathaye, 2007).
- Enhanced regional cooperation could help countries attract international mitigation funding flows by creating larger markets that are more attractive to entrepreneurs (particularly important for smaller economies), as well as facilitating technology transfer and cross-border access to renewable power sources such as hydroelectric dams. However, efforts to enhance regional cooperation must overcome complex institutional and political barriers.

8. Maximising the Developmental Outcomes of Adaptation Infrastructure Investment

In contrast to mitigation, adaptation in the infrastructure sector does not entail a step-change in technology or in the labour market. However, significant additional funding will become available from international sources and developmental outcomes will depend critically on how this funding is allocated and managed. Opportunities to maximise the developmental outcomes of adaptation infrastructure investment are very similar to those associated with infrastructure investment in general, but the case for exploiting them is strengthened by a further set of arguments. Adaptation infrastructure investment will be made in regions in which populations are experiencing negative impacts. As discussed in section 2.2.1, the most vulnerable members of society are likely to suffer most from the impacts of climate change and yet hold the least responsibility for its cause. Consequently, there is a strong case for maximising the developmental outcomes of adaptation-related infrastructure investment for these groups. Raising awareness of climate change impacts among communities and civil society will form an important part of such interventions.

This section starts with a discussion of the analogies between adaptation and development in the infrastructure sector (8.1). This section also makes the case for approaches to adaptation infrastructure that go beyond a technical focus to create holistic programmes designed to reduce vulnerability in the target population. Sections 8.2, 8.3 and 8.4 go on to identify some of the most important enablers of pro-poor

infrastructure, with specific reference to adaptation infrastructure investment. These are stakeholder engagement, community-driven projects and employment creation. Finally, section 8.5 discusses opportunities associated with regional cooperation.

8.1. Synergies between adaptation and development

The synergistic relationship between development and adaptation is summarised by the IPCC as follows:

Efforts to cope with the impacts of climate change and attempts to promote sustainable development share common goals and determinants including access to resources (including information and technology), equity in the distribution of resources, stocks of human and social capital, access to risk-sharing mechanisms and abilities of decision-support mechanisms to cope with uncertainty... Sustainable development can reduce vulnerability to climate change by encouraging adaptation, enhancing adaptive capacity and increasing resilience... Nonetheless, some development activities exacerbate climate-related vulnerabilities. (Yohe et al., 2007, p.813)

A body of climate change researchers argue that the overlap between adaptation and development is such that all development interventions support climate change adaptation and vice-versa; in effect 'stand-alone' adaptation does not exist³⁸. This

³⁸ See, for example Ayers & Huq, 2008 & 2009; Smit et al., 2001; Nicol & Kaur, 2008.

concept adds weight to the argument set out in section 3.2 that development of baseline infrastructure can be seen as a form of adaptation, since infrastructure plays a key role in promoting economic growth and reducing poverty and vulnerability.

Diverging approaches to adaptation investment – and its close relationship with development – are captured in the two different perspectives around which adaptation has typically been framed. A 'natural hazards perspective' regards the vulnerability of individuals as "created through external events and biophysical changes", whereas a 'social vulnerability perspective' sees vulnerability as a function of "the socio-economic, political and cultural factors that lead to differing social risks for segments of the population" (Jones et al., 2009: 3). The two framings lead to different policy priorities; the former generates largely technical solutions led by experts, while the latter inspires interventions aimed at reducing underlying vulnerability through empowerment and capacity building.

Both framings have value, but a strong case has been made for prioritising the social vulnerability perspective in adaptation programmes. The approaches associated with this perspective aim to enhance overall resilience, namely the technical, institutional, economic and cultural capability to cope with impacts. This can be seen as more appropriate given the future uncertainties associated with climate change impacts (Smit et al., 2001) and the limits of climate models in many developing countries (Nicol & Kaur, 2008).

Further, this type of approach is explicitly linked with overall sustainable development and is therefore likely to be more promising in promoting adaptation in the context of competing development objectives, since it is better aligned with developing country priorities (Adger et al., 2003). Even in cases where technical adaptation solutions are clearly appropriate, complementary initiatives will be needed to advance adaptive capacity (Burton et al., 2006; World Bank, 2010e).

These ideas are important for the engineering profession, where engineering projects with a narrow technical focus have often failed to generate the anticipated developmental outcomes³⁹.

8.2. Stakeholder engagement

Well-executed stakeholder engagement plays a key role in improving the developmental outcomes of infrastructure projects in the developing world. Broadly speaking, it does so by providing project-affected parties with the right to participate in decisions that affect their lives and livelihoods, by creating an environment in which all views can be heard, by responding appropriately to legitimate concerns, and by creating a sense of ownership over the investment (EAP, 2008). Involving stakeholders in adaptation project planning, design and implementation will increase the likelihood that outcomes will be appropriate to local (or regional or national) needs, as they will be informed by stakeholder perceptions of risk, vulnerability and capacity (World Bank, 2010a). Structured processes

to ensure that the voices of the most vulnerable are heard are critical to the realisation of pro-poor adaptation infrastructure investment, since it is these groups that are generally most vulnerable to climate change impacts. However, a key lesson emerging from experiences of planning for climate-compatible development is that bottom-up planning must “also coordinate with national level government and other powerful stakeholders to ensure eventual political support and uptake” (Kaur & Ayers, 2010).

In the context of adaptation, raising awareness of the likely impacts of climate change is an important element of stakeholder engagement, firstly because heightened awareness improves adaptive capacity but also in order to generate acceptance of projects that employ scarce resources for adaptation to impacts that may not yet be explicit. Stakeholder awareness facilitates anticipatory (as opposed to reactive) investment in adaptation infrastructure, thus minimising costly damage to existing infrastructure and impacts on livelihoods and human health.

8.3. Community-driven projects

The impacts of climate change are experienced primarily at local level, so adaptation is better suited than mitigation to a bottom-up process of project development, in which the local community is involved in all stages of the project (Wilbanks & Sathaye, 2007). Smaller-scale adaptation infrastructure projects are suited to so-called ‘community-driven’ schemes (World Bank, 2009), in which the community plays the role of project planner, designer and implementer, with financial and technical assistance from NGOs and / or government bodies. Examples include irrigation, rainwater storage,

small dams and flood defences, and maintenance and rehabilitation of drainage systems and gravel roads.

Well-run community-based projects provide multiple direct benefits for poor and vulnerable community members (UNDP, 2005). They generate a high ratio of employment for unskilled workers per dollar invested, since they are small or medium in scale and use low or intermediate-technology. Opportunities for paid employment reduce the vulnerability of community members, at least in the short-term. Community input into planning and design creates solutions that are appropriate to local needs and respond to the needs of the poor. The process gives the community a sense of ownership over the infrastructure, leading to greater acceptance and understanding of the asset, and hence a greater likelihood that it will be maintained. Community-led projects empower individuals by enabling them to take an active role in reducing their vulnerability, rather than being dependent upon others. Finally, the process of collective engagement inherent in community-led projects increases the level of ‘social capital’ within communities, defined by Adger (2003, p.400) as “the ability of individuals and communities to act collectively in the face of risks” – a key element of adaptive capacity.

Community-led projects also facilitate the use of traditional construction materials, such as rammed earth, wattle-and-daub, and locally-sourced stone. More widespread use of traditional construction materials increases the volume of local employment created, since the materials will be manufactured locally, and thus potentially reduces the vulnerability of community members (CIB &

³⁹ See for example World Bank (2006) Infrastructure at the Crossroads: Lessons from 20 year of World Bank Experience.

UNEP-IECT, 2002). But these construction materials also have far lower embedded carbon than commercially manufactured materials such as cement and steel, so this is an opportunity for a triple-synergy; adaptation, mitigation, and development. The advantages of using traditional construction materials must be balanced with potential concerns over durability, acceptability within the community, and appropriateness.

Researchers at the International Institute for Environment and Development (IIED) among others are advocating an approach labelled 'community-based adaptation' as a method to reach the most vulnerable and ensure a high degree of community ownership. The approach is described in Box 15, and a case study of community-based adaptation is provided in Box 16.

Interventions at community level have clear developmental benefits,

but in order to make the best use of limited adaptation resources, they will need to be balanced and coordinated with interventions at regional and national level (UNDP, 2005). Ideally, policy-makers at these different levels would be engaged in a joined-up policy framework. Failing that, they should be supported in developing an understanding of the constraints faced by the other groups (UNDP, 2005).

Box 15: Community-Based Adaptation

CBA has developed on the basis of existing community based development activities, practices, research and policies. The process begins by identifying the communities in the developing world that are most vulnerable to climate change; generally those that are very poor, depend on natural resources and live in areas that are already prone to climate shocks.

The first stage is to gain the trust of the communities, either directly (which is likely to be a time-consuming process) or through intermediaries such as NGOs, community groups and government bodies. Initial communication with the community aims to establish a joint understanding of climate change, using language and terms that community members can appreciate.

The process of identifying what adaptations are appropriate can then start. The adaptation projects identified are unlikely to look dramatically different to other development projects, but will have been designed by the community on the basis of an understanding of climate change risks.

Source: Huq, 2010

Box 16: Case study: Community-Based Adaptation to flooding and sea-level rise in Samoa

This UNDP funded project is currently under implementation in the Samoan coastal communities of Avao, Vaipouli, and Salei'a. The villages already suffer from regular flooding from a local stream and wetland which causes severe damage with the loss of homes, land, and the destruction of agricultural and livestock. Increasing climate variability and extreme weather patterns is projected to result in coastal erosion and increased flooding.



The project was formulated out of the community consultations undertaken between the village and Government of Samoa. The government's Coastal Infrastructure Management (CIM) team worked with villagers develop a Management Plan. For the implementation of the project, the villages have selected a committee that includes representation from all sectors of village; women, untitled men and village council members to coordinate the activities and provide regular feedback to the community. The only outside roles proposed will be contractors for the infrastructural works and the technical advisors providing the needed technical background for the village in making its decisions. Villagers will provide the unskilled labour for the works.

The main proposed infrastructure activity is the redirection of the stream to one of its historical pathways, further away from the villages, including the construction of a retaining wall. Additional activities include strengthening vegetation barriers against flooding, a reforestation programme for watershed conservation, and an awareness raising programme on climate change risks and adaptation.

Source: Avao/Salei'a Villages Community-Based Adaptation Project: Full Project Proposal [Online] Available from: http://www.undp-adaptation.org/projects/websites/index.php?option=com_content&task=view&id=252&Itemid= [Accessed 3rd March 2011]

8.4. Pro-poor employment generation

Adaptation infrastructure investment that does not lend itself to community-driven schemes will still create employment in the construction sector: in constructing dedicated adaptation infrastructure, in scaled-up maintenance of roads and drains due to changed climatic conditions (maintenance is particularly well-suited to labour-intensive techniques), and in retrofitting to climate-proof existing assets (World Bank, 2009). As discussed in section 7.2, construction industry jobs have high potential to generate developmental outcomes as they generate local benefits, and employ SMEs and unskilled workers. Optimising the employment generated by prioritising labour inputs where they are technically feasible and economically viable (ILO, 2004), particularly for unskilled workers, can make an important contribution to enhancing the pro-poor outcomes of the investment⁴⁰. Directing investment towards community-based projects is one approach to achieving this, but employment-intensity can also be enhanced in larger-scale, higher-technology projects. The ILO recommends two principal methods to increase the quantity of employment generated from any given investment: changing the labour/equipment balance to

⁴⁰ Optimising employment refers to the *optimal* use of labour to reach maximum effect on poverty reduction, while paying due regard to cost and quality issues. It should be distinguished from the *maximum* use of labour, often with the specific exclusion of equipment. Generally, an appropriate mix of labour and equipment is required to provide products of adequate quality in a cost effective manner.

favour the use of labour, and reducing the leakage to foreign firms through specification of local inputs (materials and equipment).

The Rwandan government has made specific reference to employment-intensive works in its NAPA, as described in Box 17.

Box 17: Case study: Employment intensive works in Rwanda's NAPA

Rwanda submitted its NAPA to the UNFCCC in 2007. The country has prioritised employment-intensive public works in its national Poverty Reduction Strategy (PRS) and this focus is also explicit in its NAPA. Of the seven priority NAPA projects identified, four include infrastructure activities that are intended to be carried out with "high manpower intensity", and this is presented as the key theme integrating the NAPA with the PRS. The planned infrastructure activities include flood protection, irrigation, water management and storage, drinking water and sanitation, and alternative energy services.

Source: NAPA-Rwanda, available at: <http://unfccc.int/resource/docs/napa/rw01e.pdf> [Accessed 2nd March 2011]

8.5. Regional cooperation

Natural resources and climate phenomena do not respect borders, so regional cooperation will be essential to deal with many of the hazards created by climate change. Water scarcity and flooding are two of the greatest risks for the developing world, and will demand more intensive and sophisticated management of regional watersheds, and thus regional engagement across governments, civil society and, in some cases, the private sector. Regional cooperation also brings important benefits in

managing risks related to sea-level rise and extreme weather events; to take an example in the infrastructure sector, countries may wish to collaborate on the construction of coastal flood defences.

Many developing countries lack the information, resources and capacity to successfully manage climate risk. Regional cooperation enables the pooling of information and resources, providing important support with tasks including the generation of climate models, and capacity-building and vulnerability and risk-assessment exercises (Smit et al., 2001). In common with mitigation, regional cooperation for adaptation will be particularly important for countries with smaller economies that have few resources to autonomously manage climate risks, as well as for countries that are exposed to risks that cross borders. Sub-Saharan Africa is perhaps the region to which regional cooperation could bring greatest benefits. As discussed in section 7.4, efforts to promote regional cooperation will need to overcome political and institutional barriers. The most promising approaches are likely to be those that building existing regional ties and models of cooperation.

Section 8: Summary of key points

- Donors will provide or leverage increasing volumes of funding for adaptation in the coming decades. Much of this funding will be allocated to the infrastructure sector, and developmental outcomes will depend on how it is managed.
- Adaptation infrastructure projects will often take place in areas in which vulnerable people are suffering from the impacts of climate change. In these instances, there is a powerful case for designing projects to maximise outcomes for the most vulnerable to the extent feasible, since these groups have lowest adaptive capacity and hold least responsibility for the emissions that have caused climate change.
- A feature of such an approach would be to formulate and implement projects with a focus on building capacity to cope with impacts and improving the resilience of livelihoods within communities in the project vicinity, rather than adopting a narrow focus on technical outcomes.
- Three tried and tested methods for generating pro-poor outcomes from infrastructure investments are: stakeholder engagement (incorporating explicit efforts to include the poorest and most vulnerable); community-led projects; and pro-poor employment creation.
- Stakeholder engagement enhances developmental outcomes in many ways, but in the context of adaptation infrastructure investment, it would support the development of appropriate solutions, informed by stakeholder perceptions of risk, vulnerability and capacity, and raise awareness of the likely impacts of climate change.
- Many adaptation infrastructure projects are well suited to community-driven schemes, for example irrigation, rainwater storage, small dams and flood defences, maintenance and rehabilitation of drainage systems and gravel roads. Implementing these projects as community-driven schemes can help to generate more unskilled employment, create ownership, empower the vulnerable, and increase social capital, which is a key element of adaptive capacity.
- Regional cooperation has a potentially very important role to play in adaptation infrastructure strategies. Coping effectively with water scarcity, flooding and sea level rise will require close cooperation between neighbouring countries. Regional cooperation also enables the pooling of information and resources for tasks including the generation of climate models, and capacity-building and vulnerability and risk-assessment exercises. Again, regional cooperation holds particular significance for countries with smaller economies.

9. Analysis of Climate-Related Infrastructure Investment Needs, Donor and CDM Infrastructure Funding Flows to Date and Low-Carbon Growth Strategies in Nine Countries

The objective of this section is to gain an improved understanding of how - and to what extent - the finance and policy development challenges discussed in previous sections are being met. Section 9.1 presents estimates of climate-related infrastructure funding required by sector and developing region (derived from reports produced by the World Bank and McKinsey and Company as described below). Section 9.2 goes on to analyse current climate-related infrastructure funding flows from the Climate Funds, the NAPAs and the CDM. The extent to which these funding flows appear to match the estimates provided in section 9.1 is commented upon, as are the possible reasons behind – and implications of – the disparities observed. Section 9.3 summarises the outcomes of an analysis of the low-carbon growth strategies of nine countries (the case studies are provided in Annex C). The analysis provides an insight into the progress to date of a selection of developing countries in developing climate policy in the infrastructure sector, as well as identifying some of the capacity, policy development, coordination and enforcement challenges they face.

9.1. Estimates of funding required by infrastructure sector and region⁴¹

⁴¹ The mitigation data given here is global, whereas the adaptation data is for developing countries only. Further, the McKinsey report represents just one possible mitigation pathway of the many available. It has been adopted as the sole source of data here as there are few such detailed and thorough analyses of

This section provides estimates of funding required for climate-related infrastructure investment by sector and region, starting with mitigation, followed by adaptation. The information is sourced from two seminal reports: firstly, McKinsey and Company's 'Pathways to a Low Carbon Economy: Version 2 of the Global Greenhouse Gas Cost Abatement Curve' (2009) (for mitigation); and secondly, the World Bank's 'The Cost to Developing Countries of Adapting to Climate Change: New Methods and Estimates' (2010) (for adaptation). There is a significant degree of uncertainty associated with these figures, which increases moving further into the future. Important sources of uncertainty for mitigation costs include progress in the development of low-carbon technologies, the future price of fossil fuels, and the nature of the post-2012 international climate regime. Significant uncertainties for adaptation costs are future climate change impacts and future rates of growth. Nevertheless, they provide an important insight into the sectors and regions that should be prioritised according to expert analysis, and thus frame the discussion of priority sectors in sections 3.1 and 3.2, and the analysis of climate change infrastructure investment flows in section 9.2.

9.1.1. Mitigation

Tables 4 and 5 provide capital expenditure estimates to reach what McKinsey and Company (2009) term

mitigation pathways that include data disaggregated by sector and region.

'global abatement potential'⁴², broken down into sectors and developing world regions. The study estimates that 67% of global abatement potential is in the developing world.

The analysis indicates that, in order to achieve the optimal abatement curve, the sector requiring greatest investment is the buildings sector by a significant margin. However, in the McKinsey model, cost savings from energy efficiency measures implemented in earlier phases of investment will begin to outweigh costs between 2026 and 2030: the net cost to society of achieving optimum abatement in the buildings sector is negative in the long term. Richer countries could potentially play a very important role in realising this transition in the buildings sector by helping to supply and/or leverage the very significant up-front costs which most developing countries would not be able to raise, supporting technology transfer, and raising awareness of the potential for long-term cost savings.

The power sector comes in second in terms of capital expenditure, but the operational cost savings are far lower than for the buildings sector, so the long term cost to society is high. These estimates depend to a high degree on technological progress in renewables and carbon

⁴² Abatement potential is defined as the maximum potential of all technical GHG abatement measures (i.e. without a material impact on the lifestyle of consumers) below €60 (\$75) per tonne, if each opportunity were pursued aggressively from 2010. McKinsey and Company estimate that this would stabilise global warming below 2°C.

capture and storage and the future price of fossil fuels.

The analysis of the cement industry has an interesting outcome: there is a net capital gain at 2015 as extensive substitution of clinker reduces the need for new-build clinker production capacity, plus the use of waste as fuel cuts the global cost of waste disposal. The net cost becomes positive after 2020 as this is when expensive carbon capture and storage (CCS) technology is anticipated to come on-line.

The analysis reveals a very substantial bias in investment needs towards Asia, and particularly China. It should be noted that this is partially dependent on the continuation of current growth and development patterns. The low estimate for Africa reflects relatively low estimates of future economic growth in that region.

When comparing investment needs with GDP, there is a substantial difference between the developed and developing worlds. Investment in developed countries represents

0.5 to 1.0% of GDP, whereas in developing countries this ratio reaches 1.2 to 3.5% of GDP (McKinsey and Company, 2009). Since the report finds that global abatement can be most efficiently achieved by making 67% of investment in the developing world, these figures illustrate the strong case for a transfer of funds from developed to developing countries on the basis of ability to pay, even without considerations of historic responsibility.

Table 4: Global capital and operational expenditure to reach full abatement potential, \$ billions annually (converted from € at a rate of \$1.25 to the €)⁴³

Infrastructure Sector ⁴⁴	2015		2030	
	Capital Expenditure	Operational Expenditure	Capital Expenditure	Operational Expenditure
Buildings	155	-30	248	-294
Power	65	4	185	-2
Iron and Steel	29	-9	43	-11
Cement	-11	-2	8	-2

Source: McKinsey and Company, 2009

Table 5: Capital investment by developing world region incremental to the business as usual scenario for the abatement potential identified, \$ billions annually (converted from € at a rate of \$1.25 to the € - for all sectors, not only infrastructure)

Region / Country	2011-15	2026-30
China	71	364
India	10	76
Rest of developing Asia	24	88
Latin America	20	65
Middle East	20	43
Africa	15	44

Source: McKinsey and Company, 2009

⁴³ The report calculates costs from a 'societal perspective' (i.e. excluding taxes, subsidies and with a capital cost similar to government bond rates). The costs also exclude transaction and programme costs to implement the opportunity at a large scale because it is very difficult to predict these accurately.

⁴⁴ Transport is absent as the report covers vehicles only, not transport infrastructure.

9.1.2. Adaptation

Tables 5 and 6 below provide estimates of adaptation infrastructure investment needs in the developing world broken down into sectors and regions.

The greatest anticipated cost is for constructing, operating and maintaining baseline levels of infrastructure services under new conditions; a cost that will vary

greatly depending on the success of mitigation initiatives, and the corresponding climate change impacts. Costs for coastal protection come in second, and are likely to continue increasing after 2050 since, for reasons explained in section 2.1, sea level rise is a very long-term phenomenon. Water supply and agricultural infrastructure also have significant associated adaptation costs.

Total infrastructure adaptation costs are greatest in Asia by a significant margin, but examining adaptation costs as a proportion of GDP reveals a different picture. Sub-Saharan Africa shoulders a far greater burden, due to a combination of the continent's vulnerability to climate change, and the low GDPs in this region.

Table 6: Annual infrastructure costs for adaptation in the developing world by sector, 2010-2050 average, \$ billions

Adaptation cost computed as the additional cost of constructing, operating and maintaining baseline levels of infrastructure services under new climate conditions	
Urban infrastructure	16.5
Roads	6.3
Health and Education	3
Power and wires	1.9
Other transport	0.9
Water and sewers	0.7
<i>Sub-total</i>	29.3
Adaptation for coastal zone protection, for medium sea level rise scenario	
Sea dikes	24.6
River dikes	0.4
Port upgrades	0.4
<i>Sub-total</i>	25.4
Water supply and riverine flood protection⁴⁵	
Industrial and municipal water supply	10.0
Flood protection	3.6
<i>Sub-total</i>	13.6
Agricultural Infrastructure⁴⁶	
Irrigation: improved efficiency and expansion	3.4
Roads	2.9
<i>Sub-total</i>	6.3
Total	74.6

Source: World Bank, 2010c

⁴⁵ Net costs taking into account reduced costs for water storage due to increased runoff. Figures for the National Centre for Atmospheric Research climate model.

⁴⁶ Figures for the National Centre for Atmospheric Research climate model.

Table 7: Annual infrastructure costs for adaptation by region, and total annual cost of adaptation as a share of GDP, 2010-2050 average, \$ billions

Region	Infrastructure Cost	Total adaptation cost as a percentage of GDP
East Asia & Pacific	21.4	0.13
Latin America and Caribbean	19.8	0.23
Sub-Saharan Africa	16.6	0.61
Europe and Central Asia	8.4	0.11
South Asia	9.4	0.14
Middle East and North Africa	2.4	0.07

Note: These figures include costs for beach nourishment of 3.3 billion annually (not counted as infrastructure in Table 6), as it was not possible to disaggregate this from the other data.

Source: World Bank, 2010c

9.2. Analysis of climate change infrastructure investment flows for Climate Funds, NAPAs and the CDM

This section summarises the outcomes of an analysis of climate change infrastructure investment flows carried out for the Climate Funds⁴⁷, the NAPAs⁴⁸ and the CDM.

⁴⁷ Bilateral and multilateral donor funds established explicitly to fund climate change activities. They do not encompass the full range of donor funding available.

⁴⁸ The NAPAs (National Adaptation Programmes of Action) are a special programme to support adaptive capacity in Least Developed Countries, funded by the GEF's Least Developed Countries Fund. The UNFCCC website describes the rationale and focus of the NAPAs as follows:

NAPAs provide a process for LDCs to identify priority activities that respond to their urgent and immediate needs with regard to adaptation to climate change. The rationale for NAPAs rests on the limited ability of LDCs to adapt to the adverse effects of climate change.... The NAPA takes into account existing coping strategies at the grassroots level, and builds upon that to identify priority activities, rather than focusing on scenario-based modelling to assess

This analysis is for **infrastructure projects only** using the definition of infrastructure given in section 1 (a full methodology is provided in Annex B). For the Climate Funds, the analysis includes funding *only for projects that have been approved*, although it should be noted that much of this approved funding has not yet been disbursed. For the NAPAs, all funding *requested* (not necessarily yet approved) has been included in the analysis, as few NAPA projects have been approved to date. Despite the lack of certainty over whether all of these projects will be realised, the analysis provides a valuable insight into the infrastructure-related adaptation priorities of Least Developed Countries. Climate Funds and NAPAs are analysed by sector, region, and country income level, whereas the CDM has been analysed by sector only as analysis of the large volume of data that would

future vulnerability and long-term policy at state level.... NAPAs are designed to use existing information; and no new research is needed. They must be action-oriented and country-driven and be flexible and based on national circumstances. (UNFCCC, 2010e)

provide a more fine-grained picture of CDM infrastructure funding flows is beyond the scope of this project⁴⁹.

Climate change donor funding (and donor-leveraged funding) is just one element of global climate change infrastructure funding, but it is intended to play a particular – and potentially very important – role. Its aims include supporting the most vulnerable countries, and helping to correct market failures in mitigation investment. The analysis here is designed to provide a broad picture of current flows, identify some of the most interesting findings, and create a platform for further discussion. However, it should be emphasised that this is an incomplete analysis of the total financial flows going to fund mitigation and adaptation infrastructure investments in developing countries. For example, at present it is not possible to summarise the very considerable

⁴⁹ However, approximately 80% of CDM registered projects can be classified as infrastructure (UNFCCC, 2010f). The discussion in section 4.1.1 on regional and country CDM flows is therefore directly relevant to the infrastructure sector.

concessional funding that flows through the bilateral and multilateral finance institutions. It would be even more challenging to analyse the substantial private investment flows which are occurring outside the CDM.

A full methodology is provided in Annex B, but some elements of the approach require explanation in order to understand the data. The analysis covers seven Climate Funds, all of which fund a significant volume of infrastructure⁵⁰. The study is based upon total project cost, including 'co-financing' of projects. Co-financing comes from a variety of sources including host country governments, other development financing agencies and donors, and the private sector. The proportion of the project budget made up by co-financing varies between projects from zero to more than 90%. The analysis makes no distinction between loans and grants provided by the Climate Funds. For both the Climate Funds and the NAPAs, analysis is by magnitude of investment (in US\$), rather than number of projects. For the CDM the analysis is by number of projects and certified emissions reductions (CERs).

The remainder of this section highlights important findings related to:

- i. the amount of infrastructure funding allocated to mitigation and adaptation for the seven Climate Funds analysed;
- ii. mitigation funding by sector, region and country income

⁵⁰ These are: GEF Trust Fund, Special Climate Change Fund (SCCF), Least Developed Countries Fund (LDCF), Strategic Priority on Adaptation (SPA), International Climate Initiative (ICI), Clean Technology Fund (CTF), Adaptation Fund.

classification⁵¹ for the Climate Funds;

- iii. adaptation funding by sector, region and country income classification for the Climate Funds and the NAPAs;
- iv. CDM projects by sector.

*9.2.1. Climate Funds:
infrastructure funding
flowing to mitigation and
adaptation*

With co-financing included, \$23 billion of project funding has been approved for mitigation, compared to \$590 million (2% of the total) for adaptation⁵². Excluding co-financing to consider direct donor funding only, the ratio changes little; \$3.2 billion for mitigation compared to \$100 million (3%) for adaptation^{53,54,55}.

That mitigation is currently receiving a considerably higher proportion of finance than adaptation is well known, although the proportion

⁵¹ Income classification is according to the OECD-DAC list of ODA recipients: <http://www.oecd.org/dataoecd/32/40/43540882.pdf>

⁵² NAPA projects are funded by the LDCF, so any approved projects would be included in the analysis.

⁵³ This ratio will change as the NAPAs approval process progresses, as LDCs have requested \$1.1 billion under the NAPAs to date.

⁵⁴ This excludes the ICI for which co-financing information is not available.

⁵⁵ The co-financing leverage ratio (i.e. dollars of co-financing leveraged for every fund dollar invested) for the six funds is 7.2 for mitigation and 5.5 for adaptation. The difference is smaller than might have been expected considering the far greater private sector interest in mitigation projects. An interesting area of further study would be to investigate what proportion of co-financing comes from the private sector for mitigation and adaptation.

allocated to mitigation appears to be particularly high in the infrastructure sector. The latest figures from the Climate Funds Update project indicate that 13.9% of overall approved donor funding has been allocated to adaptation (Climate Funds Update, 2011), compared to the figure of 3% emerging from this analysis for the infrastructure sector. The obvious conclusion is that the funding ratio is excessively skewed towards mitigation but, as discussed in section 3.3, developing an appropriate, country-specific portfolio of mitigation and adaptation activities is a complex process that depends critically on country-determined estimates of need, and much of the information required to carry out these assessments is not currently available. Without these detailed assessments the optimum allocation between these two themes will remain poorly understood.

Nonetheless, there can be little doubt that the funding currently available for investment in infrastructure-related adaptation activities is inadequate by a significant margin. As discussed above, the World Bank has estimated that developing countries will require an average of \$74.6 billion *annually* between 2010-2050 to meet the costs of infrastructure adaptation (World Bank, 2010c), while to date the Climate Funds have raised approximately \$590 million in total. Alternative sources of finance are not readily available for adaptation, although there has been much discussion on developing new, innovative sources of finance⁵⁶. As discussed in section 4.3, adaptation infrastructure is unlikely to be attractive to the private sector

⁵⁶ See for example AGF (2010) and Bapna & McGray (2008)

and funds can only be provided from the carbon market through a levy on emissions trading activities. Funding not provided (directly or indirectly) by donors is therefore likely to come principally from developing country governments' budgets in the immediate future. The small proportion of funding for adaptation infrastructure under the Climate Funds, and low volume of requests being made by developing countries compared to estimated need, is a cause for concern, and the reasons behind it merit further study.

Inadequate levels of infrastructure-related mitigation funding are also a serious cause for concern, although there is greater scope to leverage private finance for mitigation-related infrastructure investment, as discussed in section 4.3. The role of the CDM in funding mitigation-related infrastructure investment is explored in section 9.2.4 below.

9.2.2. Mitigation funding by sector, region and country income band for the Climate Funds

Mitigation Funding by Sector (Graphs 1 and 2)

The analysis reveals that energy projects dominate the Climate Funds mitigation project costs, with energy production and efficiency absorbing 58% of total funds. In contrast, just 14% of funding is allocated to the buildings sector (although this is likely to be a modest underestimate as some of the funding classified under energy efficiency will be for buildings projects). As discussed in sections 3.1 and 9.1.1, buildings is regarded as the infrastructure sector with the greatest potential for rapid and cost-effective abatement, since the energy efficiency technology already exists and many of the interventions generate a saving over the lifetime of the investment. It is

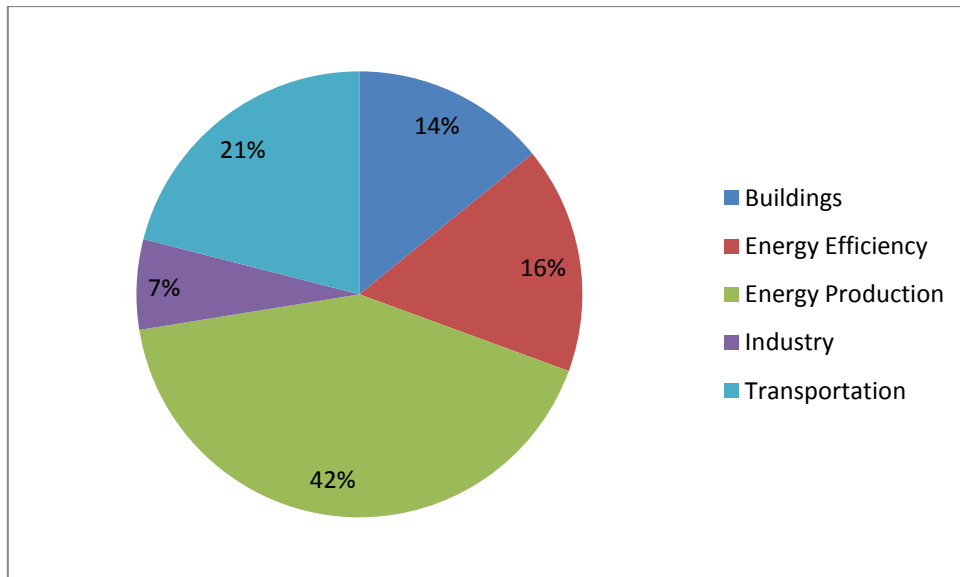
not possible to make definitive statements about the adequacy of funding flowing to the buildings sector without an understanding of private sector funding flows. However, given the importance of the buildings sector in achieving short-term emissions reductions, the reasons behind the relatively low levels of funding currently flowing to this sector from the Climate Funds merit further study.

Analysis of the sub-sectors also reveals some interesting patterns. Energy production is dominated by renewables. This is positive for job creation (cf. section 7.2), and is also an indication that some developing countries are developing a market presence in the renewable sector. No funding has been approved for nuclear energy or carbon capture and storage (CCS). This may be because funding investment in nuclear energy would be controversial due to the associated environmental risks, while CCS is still at an early and experimental stage, and therefore support from the Climate Funds would be perceived as high risk.

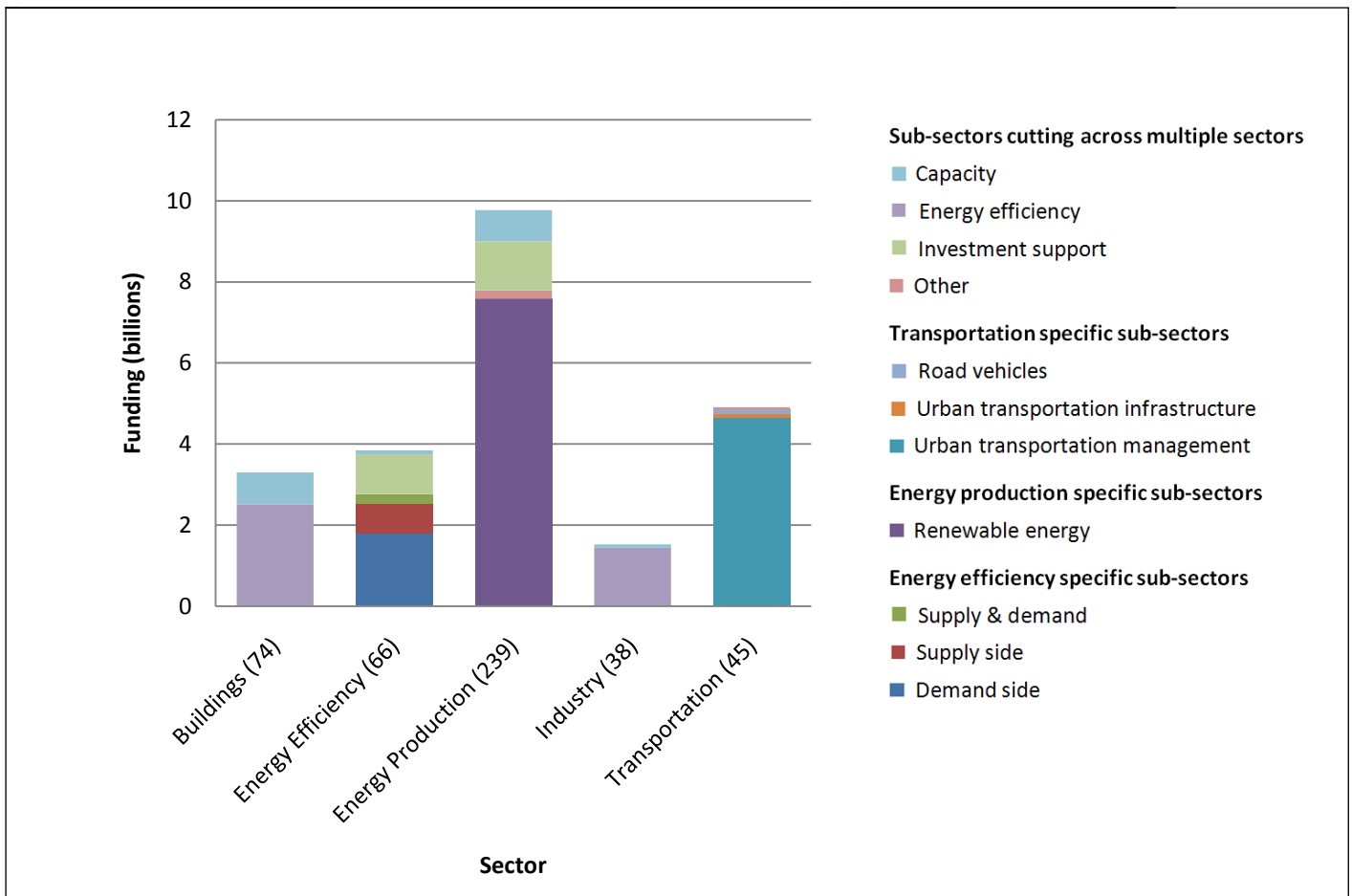
The transportation sector is dominated by 'urban transportation management', with 95% of total investment (although only 27 out of 45 projects, indicating that individual projects in this sub-sector tend to be of high value). These projects encompass multiple interventions including traffic management, rapid transit systems, greener urban vehicles and capacity-building for municipalities. Given the rapid expansion of developing country cities, investment in urban transportation management is one of the most important forms of mitigation in the transportation sector (World Bank, 2009), but also generates multiple additional developmental benefits, such as

decreased congestion, reduced air pollution, and affordable transport. The dominance of this sub-sector is likely to reflect policymakers' concerns over the growing pressure on developing country cities caused by rapid urbanisation, and their attraction to climate change projects with pronounced developmental synergies. National and regional projects are notable by their near absence.

Graph 1: Climate Funds mitigation funding by sector



Graph 2: Climate Funds mitigation funding by sector and sub-sector



Note 1: the number in brackets after the sector label is the number of projects included in the analysis.

Note 2: Energy efficiency is classified as both a sector and a sub-sector. It is classified as a sector for general projects, for example country-wide energy efficiency projects. It is classified as a sub-sector when projects are focused on one of the sector headings, for example improving energy efficiency in buildings.

Mitigation Funding by Region and Sector (Graphs 3 and 4)

The analysis shows that Asia dominates the mitigation funding from the Climate Funds, absorbing 44% of project funding. Latin American and the Caribbean has been allocated 24%, and Africa just 17%. The funding gap between Asia and Africa is in part a reflection of Asia's higher level of industrialisation and greater GDP. However, it is also likely to reflect Asian governments' greater capacity to formulate project proposals, and their more attractive investment climates.

The analysis by sector and region reveals that projects in Africa are dominated by energy production, making up 77% of the total. A recent in-depth study of the state of Africa's infrastructure concluded that energy is the continent's largest infrastructure challenge, with a funding gap of \$23.2 billion annually⁵⁷, and electricity consumption in sub-Saharan Africa barely enough to power a 100W light bulb per person for three hours a day (Foster & Briceño-García, 2010). It seems likely that the dominance of energy production projects is attributable in part to policymakers aiming to contribute to meeting one of their most urgent existing developmental needs with the assistance of the Climate Funds.

⁵⁷ 'Funding gap' is defined as total spending needs, minus existing spending, minus potential efficiency savings. By way of comparison, the report estimates that the funding gap for water supply and sanitation is \$11.4 billion, that for irrigation is \$2.4 billion, while transport and information and communications technology (ICT) would have a funding surplus if potential efficiency gains of \$1.9 billion and \$1.3 billion respectively were made.

The current massive under-production of energy in sub-Saharan Africa presents an opportunity to leapfrog directly to greener technologies as the continent develops, and to provide energy to rural areas which are difficult to supply from centralised grids, and the Climate Funds could play an important role in supporting this. However, the \$3billion approved under the Climate Funds for energy production in Africa to date falls far short of the level of investment required to realise this transition.

Funding for the buildings and transportation sectors in Africa are relatively low compared to other continents, absorbing \$170 million (4%) and \$530 million (13%) respectively. Scaling-up the funding for these sectors could bring significant benefits to the continent⁵⁸. The figure for buildings is of particular concern considering the sector's high potential for rapid and cost-effective emissions reductions, and job creation (see sections 3.1 and 9.1.1).

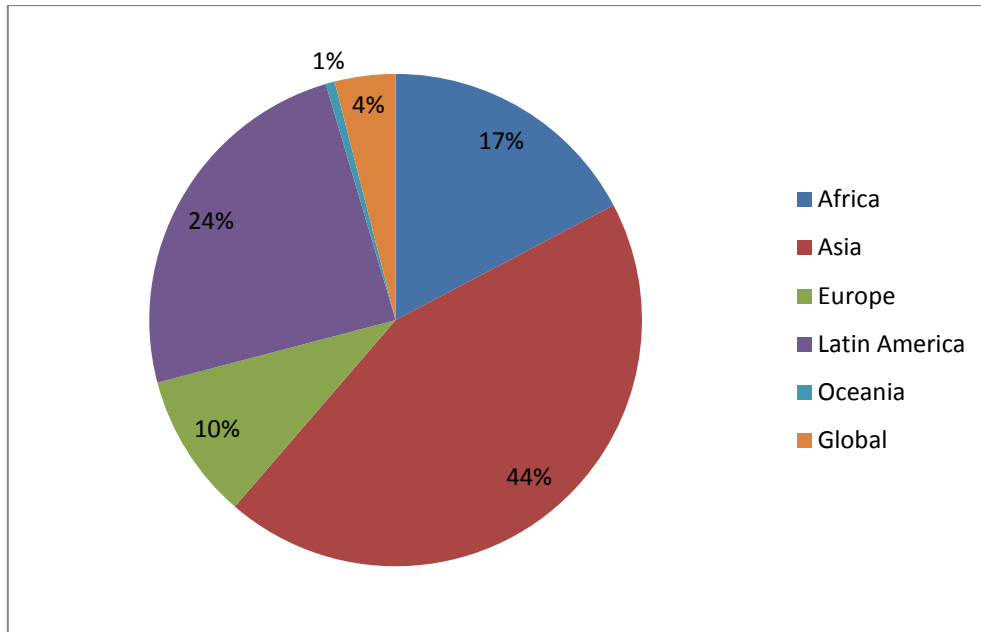
The sectoral distribution in Asia is the most balanced of the three continents, although the funding for the buildings sector remains relatively low at 8%.

Projects with donor involvement in Latin America and the Caribbean (LAC) are dominated by transportation, with 45% of total funding. This may reflect policymakers' concern with congested and polluted mega-cities in the continent. However, additional mitigation funding in Latin America is being delivered through the development banks, and it is

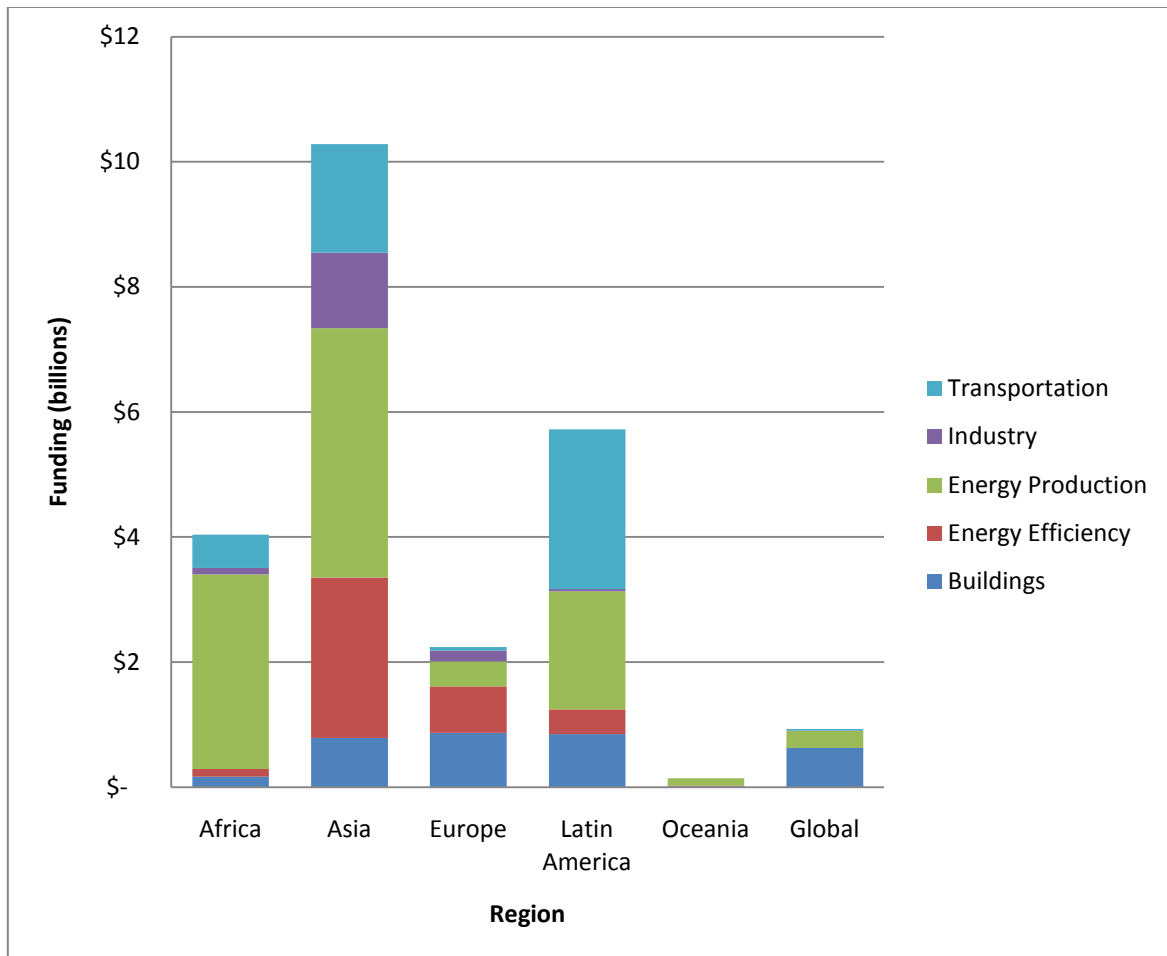
⁵⁸ An early example of scaling-up, one of the biggest mitigation projects currently funded in Africa is the USD 11 million Sustainable Public Transport project in South Africa funded by the GEF.

possible that the sectoral allocation would be more balanced with this funding included; it is impossible to say without more in-depth study.

Graph 3: Climate Funds mitigation funding by region



Graph 4: Climate Funds mitigation funding by region and sector



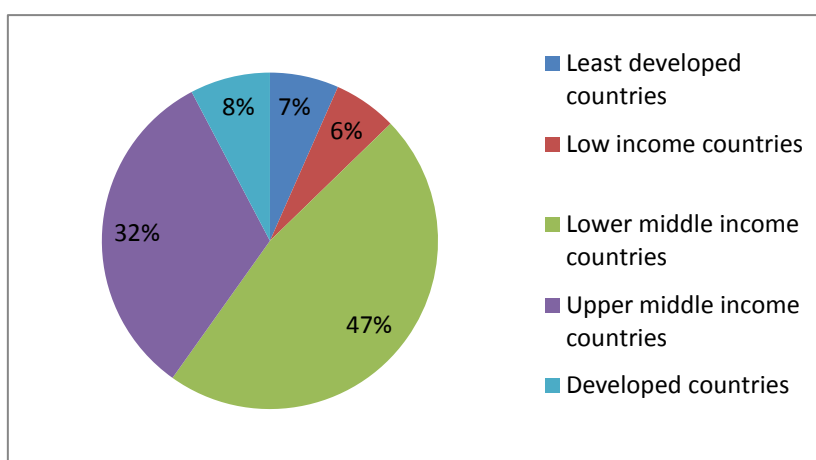
Mitigation by Income Level and Sector (Graphs 5 and 6)

The Climate Funds mitigation infrastructure projects are dominated by middle-income countries, which have absorbed 79% of total approved funding to date. In comparison, LDCs have received just 7% and LICs 6%. The principal cause of this distribution is almost certainly the greater volume of mitigation opportunities in more industrialised middle income

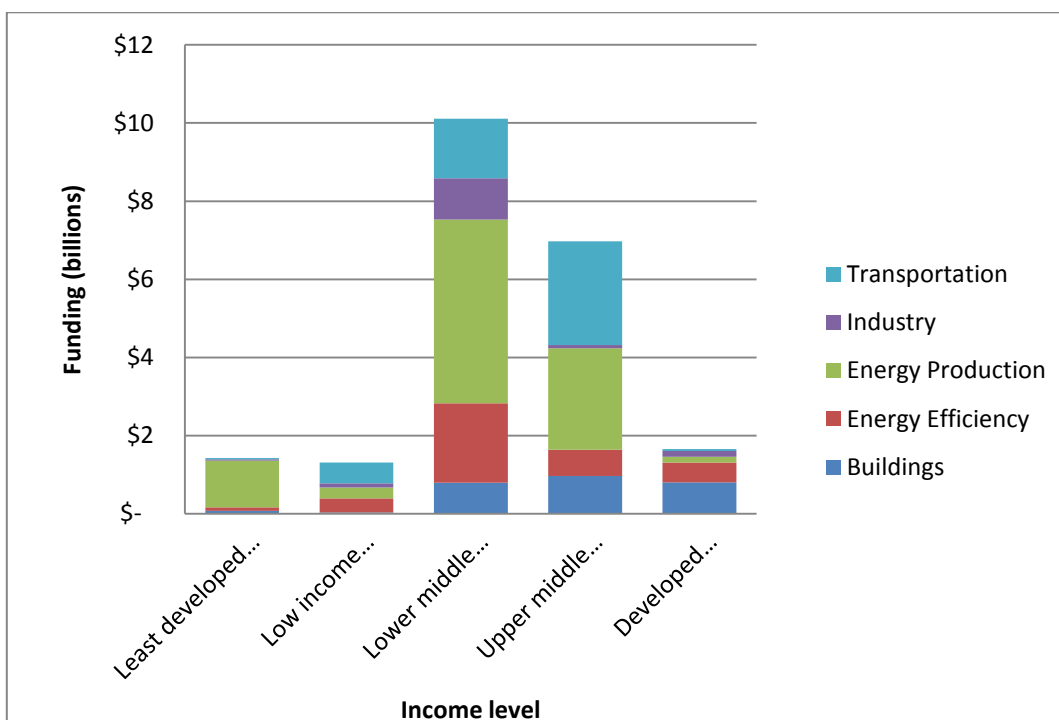
countries, as well as their larger economies. It is not possible to draw conclusions as to the optimality or otherwise of this ratio without further study of: (1) funding as a proportion of individual countries' GDP; (2) the volume of mitigation funding being made available by the private sector to different country income groups without donor co-financing; (3) the optimum distribution of abatement investment between middle-income and low-income countries.

Projects in LDCs are dominated by energy production, making up 84% of the total funding (African countries make up 34 of the 49 LDCs according to the DAC 2009-2010 classification, so this is unsurprising given the analysis of graph 4 above). The other income brackets are more balanced, although it is interesting to note the general pattern that the proportion of funds devoted to energy production decreases with income level, while the proportion devoted to buildings increases.

Graph 5: Climate Funds mitigation funding by income level



Graph 6: Climate Funds mitigation funding by income level and sector



9.2.3. Adaptation funding by sector, region and country income band for the Climate Funds and the NAPAs

For the Climate Funds, only funding for projects that have been *approved* is included in the analysis (as for the mitigation analysis above). NAPAs are funded under the Least Developed Countries Fund, so any approved projects will be included in the Climate Funds analysis. However, few NAPA projects have been approved to date, so a separate analysis has been carried out of all infrastructure projects for which funding has been *requested* under the NAPAs.

Although it is possible that not all of these projects will be approved, the analysis provides a valuable insight into the infrastructure-related adaptation priorities of Least Developed Countries.

Adaptation by Sector – Climate Funds and NAPAs (Graphs 7 and 8)

The most striking outcome of the analysis is the dominance of water projects under the NAPAs, and particularly agricultural water supply. This is in contrast to the Climate Funds projects, which are dominated by coastal zone protection. Funding from the NAPAs programme is open to LDCs only, so this is in part a reflection of the agrarian economies of most LDCs. Again, the focus on agricultural water supply reflects policymakers' prevailing concerns and understandable desire to use Climate Funds to meet the immediate needs of their citizens, where the two objectives coincide.

The NAPAs sectoral balance is in sharp contrast to the World Bank figures discussed in section 9.1.2 (World Bank, 2010c), which predict that just 5% of adaptation

infrastructure funding will be required for irrigation infrastructure⁵⁹, and 34% for coastal zone protection (just 8% of funding requested under the NAPAs is for coastal zone protection). This is at least partly attributable to the NAPAs' specific focus on meeting the "urgent and immediate needs" of LDCs, and the nature of the process of project identification, which "builds upon... existing coping strategies at the grassroots level... rather than focusing on scenario-based modelling to assess future vulnerability and long-term policy at state level" (UNFCCC, 2010e). The Climate Funds sectoral distribution is somewhat closer to the World Bank's predictions. Nevertheless, with only 2% of Climate Funds infrastructure project funding going to adaptation, the analysis raises concerns over how this more strategic, long-term adaptation infrastructure will be financed. Neither funding source includes significant support for the cost of constructing, operating and maintaining baseline infrastructure under new climatic conditions. This is the most significant sector by a good margin according to the World Bank analysis, absorbing 39% of funds.

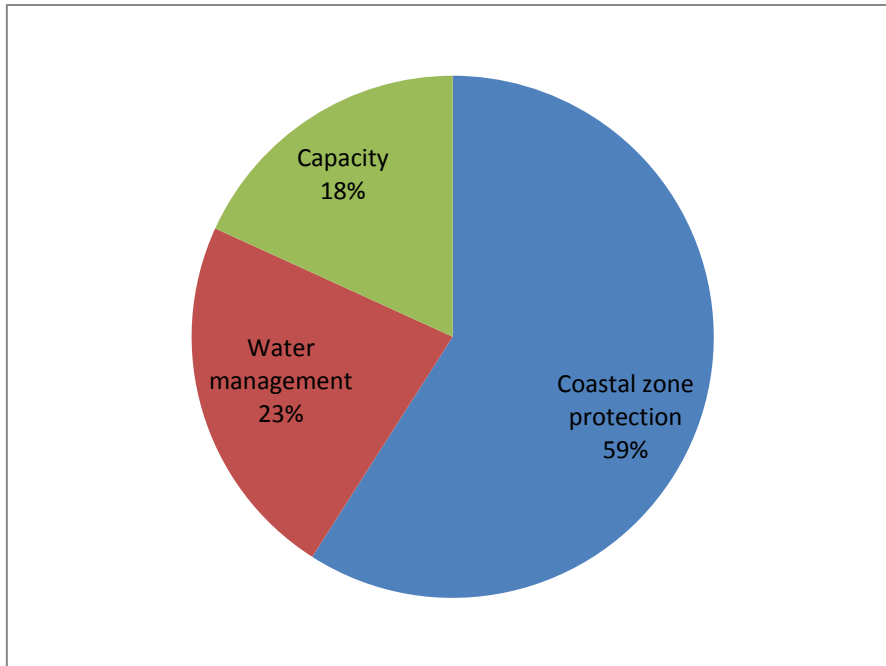
The contrast in the sectoral balance between the NAPAs and the World Bank's predictions, and the relatively low-level of funding applied for compared to that required illustrate the urgent need to build policymakers' understanding of the future impacts of climate change, their ability to develop projects, and

their access to high-quality predictive models.

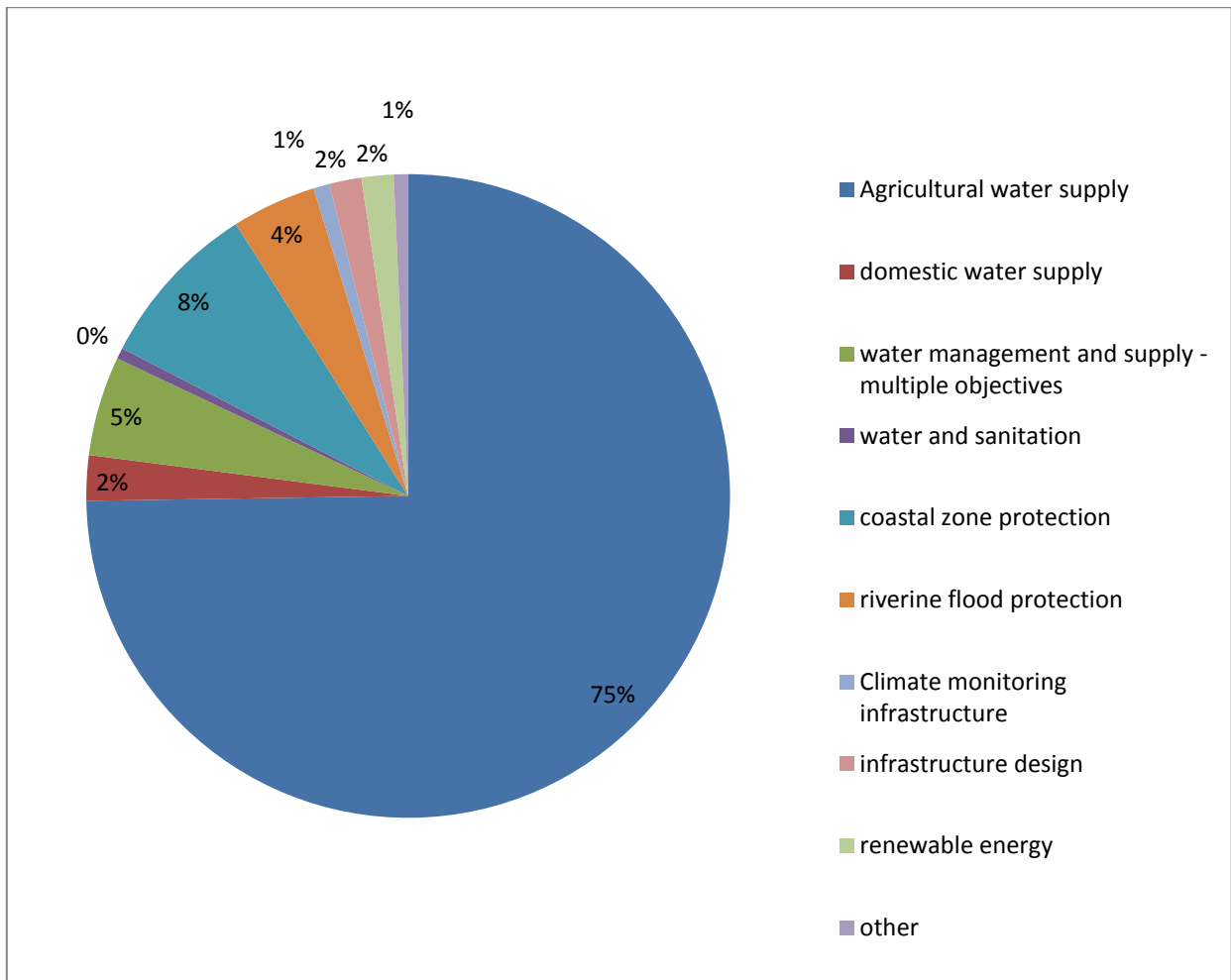
Policymakers' increasing capacity to develop project proposals will need to be matched by an increase in the funding made available through international Climate Funds for implementation of the NAPAs. That funding levels are currently inadequate is evidenced by the fact that many NAPA priority projects have not yet been implemented, despite these national plans now being three to five years old.

⁵⁹ Although, at \$3.4 billion annually, this is still considerably more than that applied for through the NAPAs.

Graph 7: Climate Funds adaptation funding by sector - \$590 million



Graph 8: NAPAs funding by sector - \$1.1 billion



Adaptation funding by region

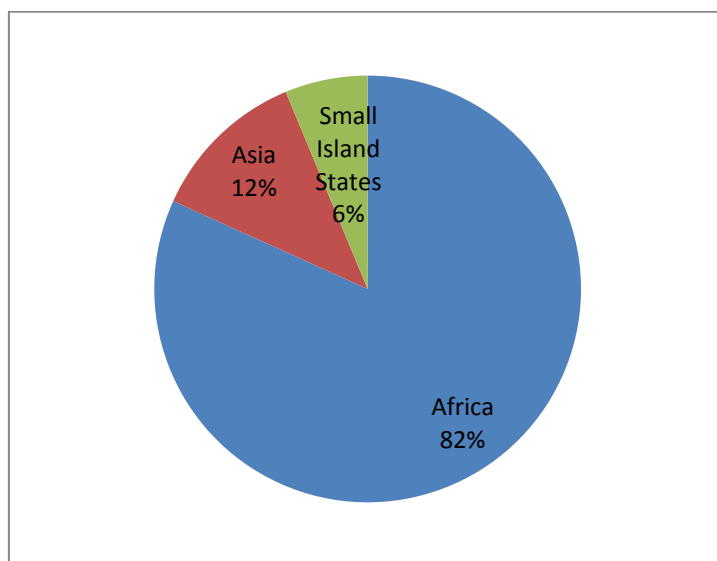
The dominance of Africa under the NAPAs is explained by the fact that only LDCs are able to apply for funding under the NAPAs and most LDCs are in Africa. Asia's 55% share of adaptation infrastructure funding under the Climate Funds is surprising, particularly when compared to Latin American and the Caribbean's (LAC's) 5%. Some possible explanations are: the

greater threat posed to Asia compared to LAC; relatively low awareness of the threats of climate change impacts among Latin American policymakers; Asian policymakers have greater capacity to develop and apply for projects; higher GDPs per capita in LAC than Asia on average, and therefore greater capacity on the part of LAC governments to absorb the impacts of climate change on their

infrastructure within their own budgets.

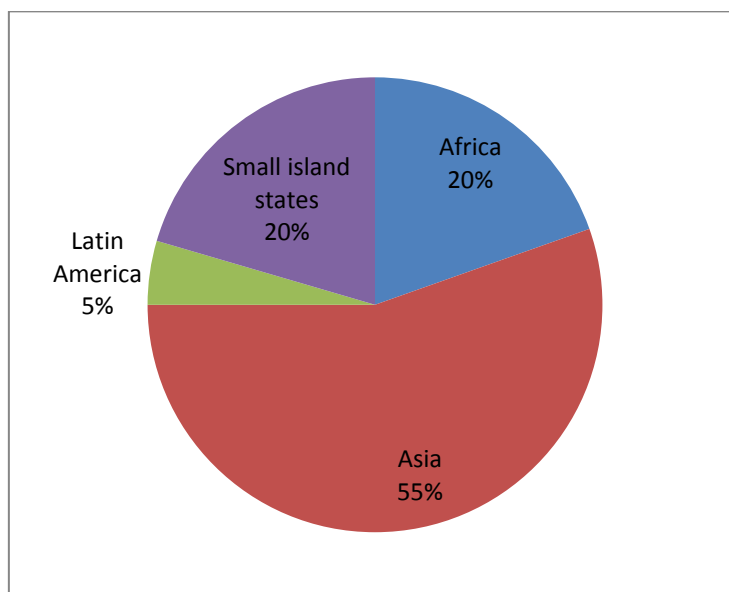
The high proportion of funding for Small Island Developing States (SIDSs) under both funding streams (relative to their GDP) indicates that policymakers in these countries are well-aware of the severe threats to their development and are acting to take advantage of the opportunities available to them.

Graph 9: NAPAs funding by region



Note: Ten small island states are included in the NAPAs analysis, of which five are in Africa (Cape Verde, Comoros, Guinea Bissau, Sao Tome E Principe and Solomon Islands), one is in Asia (Maldives), one is in Latin America and the Caribbean (Haiti) and three are in Oceania (Kiribati, Samoa and Tuvalu).

Graph 10: Climate Funds adaptation funding by region



Note: Six small island developing states are included in the Climate Funds adaptation analysis, of which two are in Africa (Cape Verde and Comoros), two are in Latin America and the Caribbean (Guyana and Haiti) and two are in Oceania (Kiribati and Vanuatu).

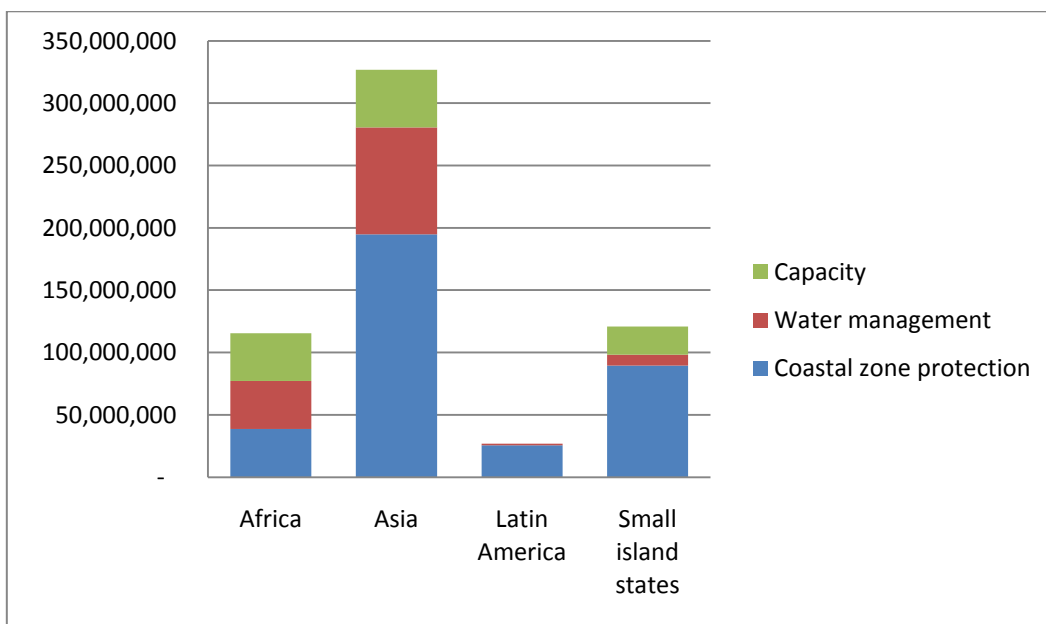
Adaptation Funding by Region and Sector (Graphs 11 and 12)

The Climate Funds analysis reveals that Africa has proportionally the highest quantity of funds for capacity building (33%), reflecting the current low capacity and the need for capacity development in these early stages of funding provision. Unsurprisingly, the

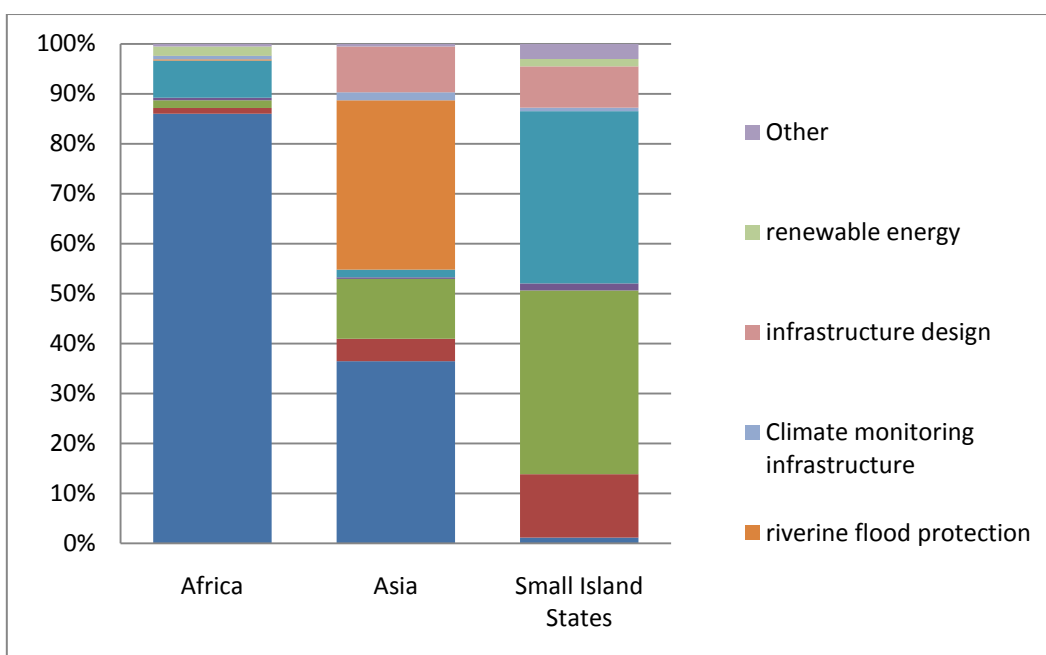
project funding for Small Island Developing States (SIDSs) is dominated by coastal protection (74% of total funding). However, under the NAPAs, the funding requested by SIDSs is evenly balanced between water management and supply and coastal zone protection, illustrating the multiple threats faced by these nations.

The analysis demonstrates that policymakers recognise the importance of developing infrastructure design for new climatic conditions; \$18 million in total has been requested for such projects. Collaboration with professionals in other countries, including the developed world, will be important in meeting these needs.

Graph 11: Climate Funds adaptation funding by region and sector



Graph 12: NAPAs funding by region and sector



9.2.4. CDM projects by sector
(Graphs 13 and 14)

In reference to the discussion of the shortcomings of the CDM in section 4.1.1, it is interesting to note the difference in the sectoral distribution when the CDM portfolio is described by number of projects or CERs. High technology projects to reduce N₂O and HFC emissions make up more than a quarter of the portfolio by CERs, but just 2% by number of projects. N₂O and HFC have very high global warming potential, and so earn high numbers of CERs, but these projects have few developmental benefits. There are clear incentives for countries with emissions reductions targets under

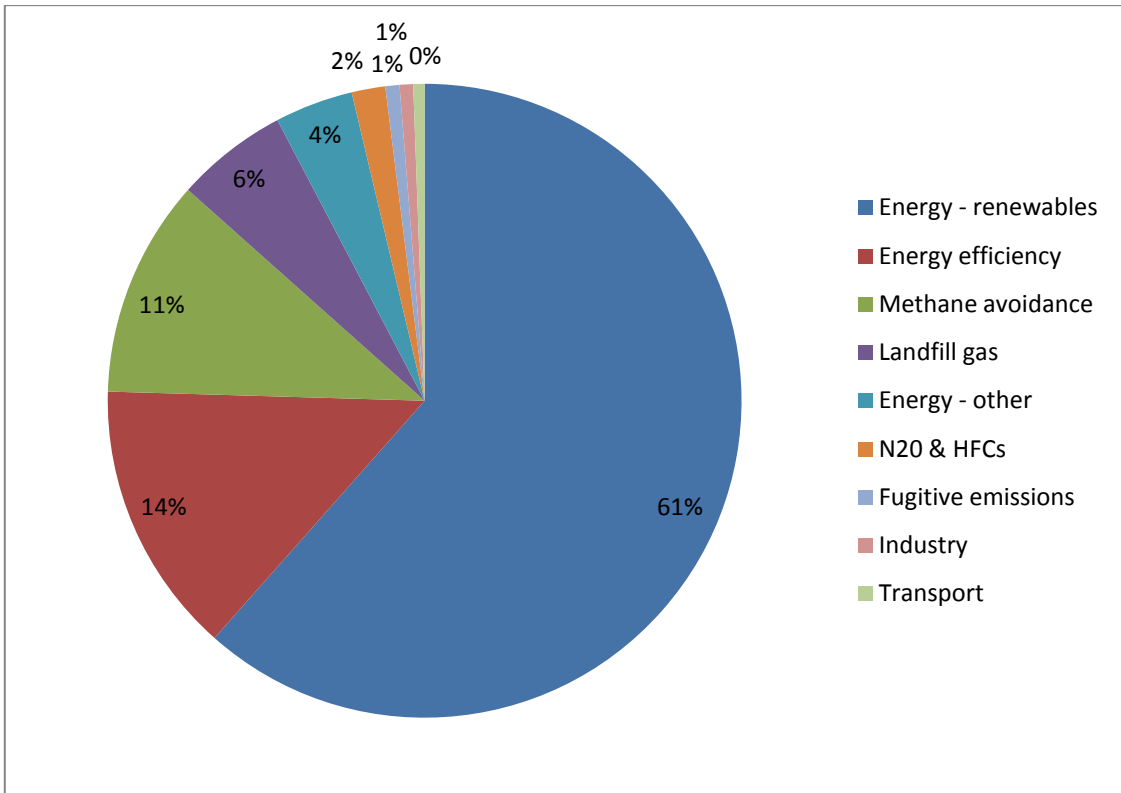
the Kyoto Protocol to achieve emissions reductions through this type of project as opposed to more complex projects with greater developmental benefits, such as transportation.

CDM projects are dominated by energy when considering either project numbers or CERs. Energy production, energy efficiency and 'energy-other' make up 79% by project number and 58% by CERs. The resources available for transportation projects under the CDM are minimal, making up just 1% of the portfolio by both project numbers and CERs. This is a concern as, as discussed in section 3.1, reducing rapidly growing emissions

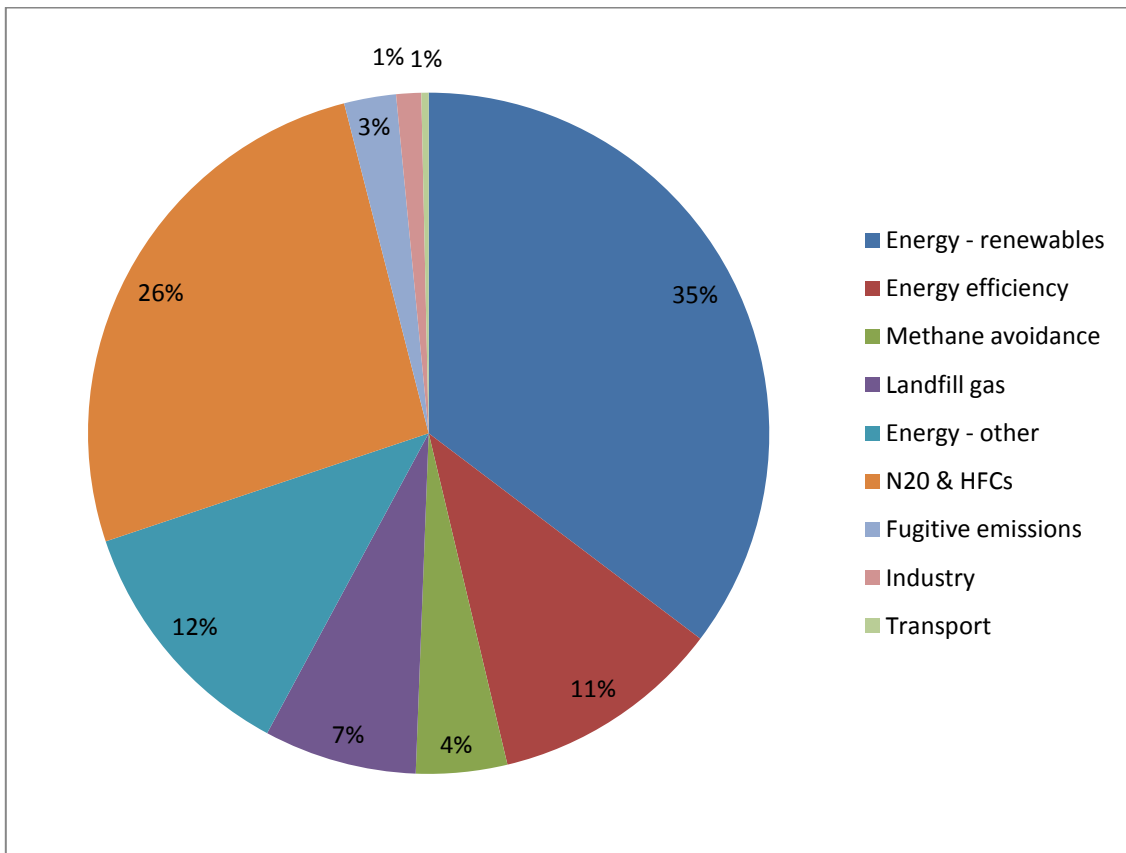
from transportation is an essential element of global efforts at mitigation.

'Buildings' has not been used as a category under the CDM, but the majority of projects classified as 'energy efficiency' are in the buildings sector. The proportion of projects or CERs for buildings is therefore relatively low – less than 14% by project numbers or 11% by CERs. Again, this reinforces the position of those advocating for change to the CDM to facilitate the inclusion of more buildings projects, in line with the most efficient distribution of global abatement finance set out in the McKinsey & Company (2009) report.

Graph 13: CDM Projects by sector by number of projects



Graph 14: CDM Projects by sector by CERs



Suggestions for Further Analysis

Further analysis that would provide a more profound understanding of the implications of this data includes:

- distinguishing between loans and grants;
- analysis of the funds flowing to certain countries or regions as a proportion of their GDP;
- the proportion of co-financing delivered by the private sector for mitigation and adaptation;
- analysis of CDM infrastructure funding flows by region and country income level; and
- analysis of other sources of climate finance in support of infrastructure projects.

9.3. Analysis of low carbon growth strategies in nine developing countries

This section provides an overview of the information obtained by carrying out case studies of the low carbon growth strategies of Bangladesh, Brazil, China, Ethiopia, Guyana, Mexico, Nigeria, Rwanda and Malawi with a focus on infrastructure policy (adaptation policies are also discussed for some countries). The country policy documents reviewed make clear that provisions related to infrastructure development, particularly energy and transportation, form the backbone of many countries' climate change plans. Infrastructure development is critical both for setting a low carbon growth trajectory and for building climate resilience, and energy and transportation are the largest sources of emissions for most countries. The studies reveal that governments have gone some way to clarifying the future direction of policy and the key decisions that will be made on infrastructure

development and energy production with a view to giving business the confidence it needs to undertake low carbon investments, although detailed plans and the policy instruments to be used are often not clearly specified.

The section starts by discussing how countries are approaching low carbon growth in the context of their energy security policies, starting with low-income countries (LICs) and moving on to middle-income countries (MICs). Low-carbon transportation strategies are then discussed. This is followed by summaries of: additional infrastructure-related low-carbon growth or adaptation policies presented in the policy documents studied; the various approaches MICs and LICs are taking to identify and take advantage by the opportunities created by mitigation discussed earlier in the report; the various measures countries are using to promote low-carbon growth and the financial incentives and regulation proposed to support these policies. The next paragraphs discuss the urgent need for finance to support climate change strategies, and the approaches countries are using to access finance. Finally, the key barriers to successful climate change policy development and implementation are summarised, as are the key shortcomings of the policy documents reviewed. There is then a brief comparison of these countries' low-carbon growth strategies with those of the UK and Germany.

Energy security is a primary objective for all countries but low carbon energy is not the only factor in achieving energy security as many of the countries studied are simultaneously developing domestic oil, gas and coal reserves.

Aspirations for lower carbon and renewable sources of energy are largely tied to income levels. Lower-income countries focus on off-grid PV, solar heating, modest amounts of wind power, wind pumping, micro-hydro, various types of bioenergy⁶⁰ and 'clean coal' technology transfer. The lowest-income countries – Ethiopia, Malawi and Rwanda – also focus on expanding usage of efficient cook stoves. Nigeria is exploring options for nuclear as well, for energy security reasons, but would need significant international support and technology transfer. In general, LICs are more vocal in their plans to harness co-benefits through increased access to clean, smoke-free forms of energy and off-grid applications that avoid costly transmission lines. The co-benefit of job creation is not a primary focus.

Middle income countries have included large-scale hydro and wind, grid and off-grid PV, cogeneration, CCS and nuclear in their plans. For some countries though, particularly poorer countries such as Nigeria and Bangladesh, it would only be possible to develop these energy sources with international assistance. Countries where coal is the primary source of energy – chiefly, Bangladesh, China, India and South Africa – are pursuing cleaner fossil fuels, including advanced coal plants, CCS, coal mine methane capture, fuel switching and development of gas fields. Others, like Ethiopia, Malawi and Rwanda, are promoting charcoal in cooking and power generation.

Transportation measures focus on mitigation from the use of biofuels, promoting public transport and

⁶⁰ Bioenergy includes biomass gasification, cogeneration and digesters.

encouraging smaller and/or more efficient vehicles. China, Brazil, Ethiopia and potentially Guyana plan to expand biofuels for transport. Brazil clearly has an advantage in bioethanol production efficiency and it is willing to export its technology to other Southern countries to enhance opportunities for global trade. Lower-income countries tend to focus only on encouraging public transport, although Ethiopia aims to impose a tax on large vehicles. China has programmes for both public transport and efficient vehicles.

Additional infrastructure policies aimed at achieving low carbon growth and climate resilience take a variety of forms. A number of MICs aim to strengthen energy efficiency and clean energy objectives in building codes; Mexico and Brazil aim to build more efficient power plants and reduce technical losses; Guyana has identified pathways to growth that are not synonymous with increasing emissions, including opportunities in business process outsourcing (BPO) to be mobilised by installing a network of fibre optic cables; Brazil aims to expand ethanol service stations. Specific infrastructure plans for adaptation tend to be most prominent in coastal countries, including Bangladesh and Guyana, which plan to build flood and seawall defences and boost disaster preparedness.

The country strategies reviewed generally have very tailored perspectives on where opportunities lie in the future with respect to climate change. Countries with the most proactive plans to harness new opportunities, all of which are seen to generate job growth and provide competitive advantage, include:

- Brazil – through trade in ethanol fuel and technology and flex-fuel vehicles;

- China – through production and export of solar photovoltaic technology;
- Guyana – through new industries in aquaculture, forest products, BPO, ecotourism, ethanol and export of fruits/vegetables; and
- Mexico – through ecotourism.

The LDCs and LICs studied are hoping for new investment opportunities through the CDM, and Rwanda is also interested in developing regional cooperation on clean electricity generation.

Generally, there is much less vision for ‘new growth’ industries and opportunities in these countries, as they are severely constrained by lack of financing and capacity.

Collaboration between the private sector, NGOs and the government is important to be able to identify and act on new opportunities, but this is generally weak in LICs.

The policy documents reviewed show that the measures used to promote low carbon growth are as diverse as their objectives. They include: financial incentives such as low-interest loans and subsidies for clean energy installations; the use of taxes to promote efficient transportation; capital subsidies, sales incentives, and reimbursement of fees for renewables projects; automatic approval for foreign direct investments as well as public private partnerships and funds to promote private sector investments into renewable energy production; fuel efficiency standards; pollution controls; and regulation to promote renewables.

These incentives and regulations are clearly crucial to the successful implementation of low carbon policies, as they represent the means through which the necessary change is brought about. However, in LICs specifically, there is little

discussion of the financial incentives or regulation with which their planned policies will be implemented, reflecting the early stage they are at in developing low carbon policies.

The low carbon growth strategy documents show that finance is fundamental to implementation and is linked to all proposals made under countries’ low carbon development plans, yet it remains scarce, particularly for LICs. Countries like Ethiopia, Malawi, Nigeria and Rwanda have no alternative specified funding source if CDM financing or international adaptation funding does not materialise. LDCs such as Bangladesh, Ethiopia, Rwanda and Malawi have stated they cannot move forward with their NAPAs without international funding.

In policy documents, countries have specified financing to come through dedicated climate change funds, government earmarks, the CDM, and requests for international support. Some countries have established climate change funds of various kinds, as a way to attract and accumulate funds for mitigation and adaptation. Some countries have targeted specific sources of finance, and are positioning themselves to achieve it. Guyana, for example has been working with various partners to develop support for its plan to finance low carbon growth through payments from the UN’s Reducing Emissions from Deforestation in Developing Countries (REDD) programme.

Most countries involve multiple ministries in both drafting and implementing proposed plans, but lack of policy coordination remains a significant barrier. Many countries seem to have conducted consultation phases between the public sector and civil society.

However, consultation of the private sector appears to have been more limited in most countries, which could potentially reduce the feasibility of implementation, if plans are not based on market conditions and realities. One key exception is Guyana, which seems to have benefited by working closely with a range of partners including business to develop its comprehensive proposal. Nigeria also used technical working groups including private sector representatives to recommend specific target technologies and strategies.

A significant shortcoming in most of the policy documents is that they do not spell out specific actions that will be taken or specific implementation plans. Countries such as Guyana have specified the actions they will take in a certain timeframe, but other plans, such as those for Brazil or Ethiopia, offer few details on how they intend to carry out their plans. A few countries suggest that they will work out guidelines in future consultations, and others delegate certain ministries to be in charge of future implementation. Most of the policy documents are more statements of intent than plans of action however.

Overall, in MICs the biggest issue seems to be a lack of coordination between implementing bodies, unaligned policies and weak enforcement at the local level. In LICs, capacity represents the most significant barrier to

implementation, including lack of training and expertise in climate change issues and weak enforcement and oversight. Therefore, key requirements for developing countries to successfully implement their plans include the need to build capacity, and enhance coordination between ministries, as well as wider steps to provide adequate public finance and improve the investment climate and market mechanisms in order to stimulate private financing.

Comparison with low-carbon growth strategies of the UK and Germany

It is instructive to compare these developing country case studies with the strategies of the UK and Germany – briefly described below. Although both countries have adopted relatively ambitious targets, the difficulties faced in achieving them are clear.

The United Kingdom and Germany have both adopted targets beyond what is required of them by the Kyoto Protocol. The UK is bound by its own laws to reduce emissions by 26 – 32% by 2020 against 1990 baseline levels, and 80% by 2050 (however, the UK missed its interim target of a 20% reduction by 2010 by a significant margin). Germany has adopted a target of 40% emissions reductions by 2020.

Both countries have developed strategies to take advantage of new opportunities presented by the green economy, although Germany's strategy is more far-reaching. The

UK has produced a strategy paper ("Investing in a Low Carbon Britain", 2009) identifying areas in which Britain should be seeking to take advantage of the market for green products, these being: carbon capture & storage technologies, offshore wind farms, marine energy, nuclear power and low carbon vehicles. Amongst developed countries, Germany is exceptionally proactive in developing strategy to benefit from the growing green economy. Germany estimates the value of the global green growth sector at around €1,500 billion a year currently, with the potential to increase to €3,000 billion by 2020. The government is making targeted investments in green research and development, with the aim of making Germany a world leading exporter in the field, and thus facilitating the creation of between 500,000 and 1 million new jobs by 2020.

Broad and thorough public and private consultation was carried out during the development of the UK strategy. Groups consulted include NGOs, members of civil society, academic institutions and representatives of the private sector. The consultation process for the German strategy is less clear - the German government states that broad consultations have occurred, but the specifics of these consultations are not detailed in publicly available documentation.

Section 9: Summary of key points

Funding needs

- According to estimates in the report “Pathways to a Low Carbon Economy: Version 2 of the Global Greenhouse Gas Cost Abatement Curve” (2009): 67% of global abatement potential is in the developing world and, in order to achieve the optimum global abatement curve:
 - the infrastructure sector requiring greatest investment is the buildings sector by a significant margin (\$155 bn and \$248 bn annually globally⁶¹ in 2015 and 2030 respectively), although, due to the resulting cost savings, the net cost to society of achieving optimum abatement in the buildings sector is negative in the long term;
 - the power sector comes in second in terms of capital expenditure (\$65 bn and \$185 bn annually in 2015 and 2030 respectively), but the operational cost savings are far lower than for the buildings sector, so the long term cost to society is high;
 - the developing region requiring greatest investment by far is Asia.
- According to estimates in the World Bank report “The Cost to Developing Countries of Adapting to Climate Change: New Methods and Estimates” (2010):
 - \$74.6 billion annually on average will be required in developing countries for adaptation investment in the infrastructure sector between 2010-2050;
 - the greatest anticipated cost is for constructing, operating and maintaining baseline levels of infrastructure services under new conditions (39%), followed by coastal zone protection (34%), water supply and riverine flood protection (18%), and agricultural infrastructure (8%);
 - total infrastructure adaptation costs are greatest in Asia by a significant margin, but sub-Saharan Africa will shoulder a greater burden proportionally: 0.6% of GDP compared to 0.1% in Asia.

Analysis of donor funding flows

- Infrastructure funding flows for approved projects from seven Climate Funds were analysed. \$3.2 billion of direct donor funding had been raised for mitigation up to September 2010, and \$100 million (3%) for adaptation⁶². Considering full project cost including co-financing leveraged, \$23 billion has been allocated to mitigation and \$590 million (2%) to adaptation. While it is difficult to make statements about the appropriate balance between mitigation and adaptation without country-level detailed assessments of needs, these figures suggest that donor infrastructure funding flows may be excessively skewed towards mitigation.
- Donor funding for adaptation is currently inadequate by a significant margin; the Funds have raised \$590 million in total to date, whereas the World Bank has estimated that \$74.6 billion annually will be required on average from 2010 - 2050. Alternative sources of finance are not readily available for adaptation, so funding not provided (directly or indirectly) by donors is likely to come principally from developing country governments’ budgets in the immediate future. Scaled up donor funding, combined with new and innovative funding strategies will be needed to meet adaptation infrastructure funding needs.

⁶¹ Disaggregated figures for the developing world are not available.

⁶² This is not an analysis of the total donor funding flows as it does not include concessional funding that flows through the bilateral and multilateral finance institutions, or private investment flows occurring outside the CDM.

Mitigation: Climate Funds

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| <ul style="list-style-type: none"> • Energy projects dominate the Climate Funds mitigation project costs, with energy production and efficiency absorbing 58% of total funds. • The buildings sector is receiving just 14% of project funding provided or leveraged by the Climate Funds. It seems probable that this is lower | <p>than the optimum given the outcomes of the McKinsey and Company analysis, although it is difficult to come to any firm conclusions without an understanding of the sectoral distribution of private investment.</p> <ul style="list-style-type: none"> • Many of the projects are clearly designed to contribute to national | <p>developmental objectives as well as mitigation. For example, 95% of transport project costs are allocated to urban transportation management which will contribute to increased mobility and reduced air pollution as well as emissions reductions.</p> |
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Adaptation: Climate Funds and NAPAs

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| <ul style="list-style-type: none"> • Adaptation infrastructure funding requested under the NAPAs is dominated by agricultural water supply, with 75% of the total⁶³. In contrast, approved funding under the Climate Funds is dominated by coastal protection, with 59%. Funding from the NAPAs programme is open to LDCs only, so this is in part a reflection of the agrarian economies of most LDCs. The focus on agricultural water supply reflects policymakers' prevailing concerns and understandable desire to use Climate Funds to meet the immediate needs of their citizens | <p>where the two objectives coincide.</p> <ul style="list-style-type: none"> • The NAPAs sectoral balance is in sharp contrast to the World Bank figures discussed in section 9.1.2 (World Bank, 2010c), which predict that just 5% of adaptation infrastructure funding will be required for irrigation infrastructure, and 34% for coastal zone protection. This is at least partly attributable to the NAPAs' specific focus on meeting the "urgent and immediate needs" of LDCs but, with only 2% of Climate Funds infrastructure project funding going to | <p>adaptation, the analysis raises concerns over how this more strategic, long-term adaptation infrastructure will be financed.</p> <ul style="list-style-type: none"> • The contrast in the sectoral balance between the NAPAs and the World Bank's predictions, and the relatively low-level of funding applied for compared to that required illustrate the urgent need to build policymakers' understanding of the future impacts of climate change, their ability to develop projects, and their access to high-quality predictive models. |
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The Clean Development Mechanism

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| <p>CDM projects are dominated by energy when considering either project numbers or CERs. Energy production, energy efficiency and 'energy-other' make up 79% by project number and 58% by CERs. The resources available for transportation projects under the</p> | <p>CDM are minimal, making up just 1% of the portfolio by both project numbers and CERs.</p> <ul style="list-style-type: none"> • The proportion of projects or CERs for energy efficiency in buildings is lower than the McKinsey and company analysis suggests is optimal: less than 14% by project | <p>numbers or 11% by CERs.</p> <ul style="list-style-type: none"> • These findings illustrate the case for making alterations to the way the CDM functions in order to encourage the inclusion of transportation and buildings projects. |
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⁶³ For the Climate Funds, only funding for projects that have been *approved* is included in the analysis. Few NAPA projects have been approved to date, so the analysis has been carried out of all infrastructure projects for which funding has been *requested* under the NAPAs.

Case studies of low-carbon growth strategies in nine countries

The following are the key findings from case studies of low-carbon growth strategies in Bangladesh, Brazil, China, Ethiopia, Guyana, Mexico, Nigeria, Malawi and Rwanda:

- Provisions related to infrastructure development, particularly energy and transportation, form the backbone of many countries' climate change plans. Low-carbon growth strategies in the infrastructure sector vary considerably between country income brackets. Proactive plans to harness opportunities from national mitigation strategies are more evident in MICs than LICs.

- In the LIC documents reviewed, there is little discussion of the financial incentives or regulation with which their planned policies will be implemented, reflecting the early stage they are at in developing low carbon policies.
- The low carbon growth strategy documents show that finance is fundamental to implementation and is linked to all proposals made under countries' low carbon development plans, yet it remains scarce, particularly for LICs.
- Consultation of the private sector appears to have been limited in most countries.
- Overall, in MICs the biggest issue seems to be a lack of coordination

- between implementing bodies, unaligned policies and weak enforcement at the local level. In LICs, capacity represents the most significant barrier to implementation, including lack of training and expertise in climate change issues and weak enforcement and oversight.
- Therefore, key requirements for developing countries to successfully implement their plans include the need to build capacity, and enhance coordination between ministries, as well as wider steps to provide adequate public finance and improve the investment climate and market mechanisms in order to stimulate private financing.

10. Conclusions, Recommendations, and Areas for Further Study

This report has aimed to provide an overview of the challenges and opportunities at the nexus of climate change, infrastructure and development. It has approached this through the following objectives:

1. Describe the transformation required in the infrastructure sector to promote low-carbon growth and climate-resilient development.
2. Identify the key challenges to achieving this transition within the required timeframe in the developing world, and the strategies that have been developed to date to meet these challenges. Take preliminary steps towards identifying the further action likely to be required.
3. Explore potential developmental opportunities associated with international and national efforts at mitigation and discuss, in general terms, how they can be realised.
4. Identify approaches to maximising the developmental outcomes of adaptation investment in the infrastructure sector.
5. Analyse climate-related infrastructure funding flows from donors and the Clean Development Mechanism (CDM), compare these with estimated needs, and draw preliminary conclusions from the trends observed.
6. Develop an improved understanding of the reality of climate change policy development in the infrastructure sector by studying the infrastructure-related low-

carbon growth strategies of nine countries.

7. Draw conclusions and make recommendations based on the above, and identify priority areas for further study.

A summary of some of the most important conclusions is provided below. Those wishing to gain a more complete picture of the conclusions of this research may refer to the summary boxes at the end of each main section. This is followed by recommendations, incorporating areas for further study. The recommendations are directed towards donors although, since they identify various policy interventions and areas for further research, they will also be of interest to developing country policymakers, academics, NGO researchers and professionals.

10.1. Conclusions

Infrastructure and the engineering profession play a crucial role in efforts to reduce emissions sufficiently to prevent irreversible damage to global climate and ecosystems, and to adapt to the climatic changes that have become inevitable.

Action in the infrastructure sector is urgent, as infrastructure assets have a long life span and rates of infrastructure investment are high in many countries. Inaction could lead to countries becoming 'locked-in' to high-carbon growth paths during a period which is critical for the climate, and developing infrastructure stocks that are not suited to new climatic conditions. Such an outcome would compromise developmental goals.

This report has identified three key barriers to meeting the challenge of

climate change in the infrastructure sector in the developing world: accessing sufficient finance, making the necessary technological process within the timescale required, and limited capacity within national governments to develop and implement climate change policy.

The volume of funding required to meet mitigation and adaptation needs in the infrastructure sector in the developing world within the timescale required are vast. Developing countries do not have access to funding on the scale required, nor should they be expected to provide it given the global distribution of responsibility for emissions and the global distribution of wealth. North-South financial transfers are occurring through donor funding and market mechanisms, but are currently massively inadequate, and there are questions over whether these funds are being allocated optimally (or even close to optimally) between adaptation and mitigation, between country income brackets, and between infrastructure sectors.

Technological progress plays a crucial role in reducing emissions in the infrastructure sector, and also has an important part to play in protecting communities from the impacts of climate change. Technology transfer will need to be scaled up dramatically to meet technological needs within the short window of time available, but this will need to be combined with programmes to enhance the capacity of developing countries to absorb new technologies, and their capacity to develop technologies particular to their needs.

The scale and urgency of the climate change challenge demands an ambitious response, yet developing

countries can only take actions that are consistent with their capacity level. National governments' success in coping with climate change will depend to a large degree on their ability to develop coherent climate change policy frameworks that: integrate climate change objectives with national plans and budgetary frameworks; facilitate integrated climate change planning across sectors and scales; and support the mainstreaming of mitigation and adaptation objectives routinely into policy decisions across a broad spectrum. This is difficult to achieve in many developing countries due to institutional weaknesses, poor access to information and modelling, low levels of human capacity, and inadequate financial resources. Building the capacity of developing country governments to formulate and implement climate change policy will therefore form an important part of programmes to support developing countries in meeting the challenge of climate change, and support from high-income countries will be critical in achieving this.

The consequences of climate change are often seen as overwhelmingly negative for developing countries, but developmental opportunities are also created by international and national policies for mitigation and adaptation in the infrastructure sector.

Opportunities associated with mitigation include: access to new sources of international finance and international markets; technology transfer; the creation of additional 'green' jobs, particularly in the renewable energy and buildings sectors; and development win-wins created by synergies between national mitigation strategies and development priorities. Developing country governments will be better

placed to harness the opportunities associated with mitigation in the infrastructure sector if they are able to: develop a coherent and clearly articulated mitigation strategy; develop a national strategy to capture the employment benefits of the transition to a low-carbon economy in the labour market; identify and exploit synergies between mitigation strategies and national development priorities; cooperate more closely with neighbouring nations to win international investment and share technology and resources.

Donors will provide or leverage increasing volumes of funding for adaptation in the coming decades. Much of this funding will be allocated to the infrastructure sector, and developmental outcomes will depend upon how it is apportioned and managed. Given that the most vulnerable people in society have least capacity to adapt to climate change, but are least responsible for its causes, there is a powerful case for designing projects to maximise outcomes for the most vulnerable to the extent feasible. Three tried and tested methods for maximising the pro-poor outcomes of infrastructure investment are: stakeholder engagement (incorporating explicit efforts to include the poorest and most vulnerable); community-led projects; and pro-poor employment creation.

The outcomes of case studies of low-carbon growth strategies in nine developing countries suggest that, in middle-income countries, the greatest barrier to successfully developing and implementing strategies in the infrastructure sector is a lack of coordination between implementing bodies, unaligned policies and weak enforcement at the local level. In

low-income countries, capacity represents the most significant barrier to implementation, including lack of training and expertise in climate change issues and weak enforcement and oversight. This leads to the conclusion that key requirements for developing countries to successfully implement their plans include the need to build capacity, and enhance coordination between ministries, as well as wider steps to provide adequate public finance and improve the investment climate and market mechanisms in order to stimulate private financing.

10.2. Recommendations and areas for further study

The recommendations given are directed towards donors, but would also be of interest to developing country policymakers, researchers and infrastructure professionals.

Recommendations for donors

Support programmes to raise awareness amongst developing country policymakers, the private sector and civil society of the urgency of taking action in the infrastructure sector in order to avoid becoming 'locked-in' to high-emissions pathways and developing infrastructure stocks that are not suited to new climatic conditions.

Support partner country governments in developing and implementing climate change policy frameworks:

- Support the development of decision making frameworks to help countries identify and prioritise mitigation and adaptation-related infrastructure investment needs, and balance these needs with developmental priorities.
- Raise awareness amongst policymakers in the developing world of the potential synergies

between mitigation, adaptation and development, and support the development of tools to facilitate the identification and capture of these synergies.

- Support partner country governments in developing strategies to overcome the barriers to rapid, cost-saving emissions reductions in the buildings sector as a priority. These would include updated and better-enforced building codes, financial incentives, and education and awareness-raising.
- Assist partner country governments in preparing the infrastructure sector for climate impacts that are still uncertain. Possible approaches include: support governments in implementing cost-effective measures to climate-proof future baseline infrastructure, such as changes to building codes and climate-risk assessments at planning stage; build the capacity of infrastructure decision-makers to identify options for dedicated adaptation infrastructure that are 'no-regrets' or 'low-regrets', i.e. that are robust under most climate scenarios.
- Lead by example by adopting climate risk assessments as standard in project planning for donor supported infrastructure projects and disseminate the tools and knowledge generated⁶⁴.
- Support developing country partner governments in engaging in broad-based consultation during the development of low-carbon growth strategies, including consultation with civil society and the private sector.

Support programmes to build capacity in partner country governments, the private sector and civil society:

- Work through existing channels of development assistance to build capacity for integrating climate change into developmental decisions in the relevant government institutions.
- Develop capacity-building strategies for climate change in the infrastructure sector in partnership with partner country governments, with input from the private sector and professional institutions, and on the basis of an understanding of the existing capacity and institutional characteristics of the agencies most appropriate to take a leading role in climate-related infrastructure policy development.
- Build the capacity of developing country policymakers (particularly in lower-income countries) to develop mitigation and adaptation-related infrastructure project proposals for international funding.
- Support programmes to build the capacity of 'green workers' who could benefit from the jobs created by transition to a low-carbon economy in the labour market.

Scale-up, balance and coordinate funding flows for climate-related infrastructure:

- Scale-up donor funding flows for climate-related infrastructure investment in order to enable developing countries to achieve mitigation and adaptation goals within the timescale required.
- Scaling up funding for adaptation infrastructure investment appears to be particularly urgent as this study has found a very high proportion of donor funding for infrastructure flowing to

mitigation, and there is little scope to raise adaptation funding from private sources.

- In order to make the best use of limited donor funds, exploit synergies with existing financial flows - including existing aid transfers - and improve the coordination of donor contributions across sectors, countries and regions.

Maximise the pro-poor outcomes of donor-supported adaptation infrastructure projects:

- Combine investment in physical infrastructure with programmes to enhance adaptive capacity and the resilience of livelihoods.
- Adopt community-led approaches to adaptation infrastructure projects where possible, with the aim of generating benefits including employment generation, ownership, empowerment, and enhanced social capital.
- Develop a stakeholder engagement plan that incorporates explicit strategies to include the poorest and most vulnerable.

Support efforts to mobilise private sector support for climate-related infrastructure investment:

- Encourage private sector investment in green infrastructure in countries with challenging investment climates by providing risk mitigation in the form of guarantees, grants and loans.
- Support developing country partners in creating incentives for private investors to adapt new physical assets to climate change impacts.

Support reforms to the CDM:

- Support reforms to the CDM which would result in the allocation of a greater proportion of CDM financing to the key infrastructure

⁶⁴ Some donors are already making progress in this area; see section 3.2.

sectors of transport and the built environment, and to a wider range of country income groups. One possible approach would be funding research to model the outcomes of various possible reforms, thus creating a stronger evidence base for pro-reform positions in international negotiations.

Support scaled-up technology transfer and innovation at international, regional and national level:

- Combine international initiatives to promote technology acquisition with programmes to build absorptive capacity in developing countries. Such programmes would support any or all of: the development of technical expertise, strengthening of legal frameworks to protect intellectual property rights, the creation of institutions able to promote and coordinate technology transfer.
- In addition, support national and/or regional programmes to develop technologies required specifically for developing country contexts, such as low-cost decentralised renewable energy for mitigation, and small-scale irrigation for adaptation.

Areas for Further Study (for donors or others)

Compile evidence in key areas and support the development of policy accordingly:

- Compile evidence of the developmental benefits of switching from high-emissions development to low-emissions pathways (particularly for lower-income countries), and the policy frameworks that optimise these developmental outcomes.
- Compile evidence on the potential for pro-poor green job creation in

the buildings sector, and provide support in developing policy to capture these benefits.

- Research the costs associated with regulating for reduced emissions and climate robustness in the infrastructure sector. Use this to support the development of mechanisms to compensate developing country governments and private sector actors for these costs, thus providing incentives to implement and enforce climate-related regulations.
- Further research is required into the implications of the high proportion of construction activities that take place in the informal sector in developing countries for attempts to reduce emissions and prevent maladaptation through regulation, and potential approaches to reducing this barrier.
- The analysis of funding flows in this report raises several concerns and demonstrates the need for a more extensive analysis of climate-related infrastructure funding flows by sector, and by mitigation and adaptation, including – as far as is possible – donor funding flows beyond the Climate Funds and private sector flows. The analysis could be used to understand whether the very high proportion of funding flowing to mitigation found in this study still stands when a wider range of funding sources are taken into account, as well as providing valuable evidence on the allocation of infrastructure funding flows between sectors and countries. Of particular importance is further investigation into whether the buildings sector is receiving the support needed to realise the substantial and cost-effective mitigation opportunities it presents.

- Further research is required into the potential benefits of, and obstacles to, regional cooperation for adaptation and mitigation programmes in the infrastructure sector, possibly with a focus on sub-Saharan Africa. One focus area would be existing regional groupings and models of cooperation, and the extent to which these can be built upon for climate change programmes.

Areas in which research has already been carried out, but additional evidence and case studies would be valuable:

- The role of public-private partnerships in promoting green investment in, and technology transfer to, the developing world.
- Procurement strategies to encourage low-carbon, climate resilient infrastructure development.

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Annex A: Examples of Synergies in the Infrastructure Sector – Mitigation, Adaptation, Development⁶⁵



⁶⁵ The figure is for illustrative purposes and is far from comprehensive, while judgements made on the existence of synergies will always be somewhat subjective. In this illustration, climate change investment is classified as synergistic with development where the benefits go beyond returning to the pre-climate change status quo in the case of adaptation, or beyond simply reducing GHG emissions in the case of mitigation.

Annex B: Climate Infrastructure Investment Flows Analysis Methodology

For both the Climate Funds and the NAPAs, analysis is by magnitude of investment (in US\$).

B.1 Climate Funds analysis

B.1.1 Selection of Climate Funds to be included

Initially, a full list of funds was downloaded from the Climate Funds Update Website, administered by the Overseas Development Institute and the Heinrich Boll Foundation: <http://www.climatefundsupdate.org/listing>.

Decisions were then taken on which funds to include and which to exclude. Included funds are: GEF Trust Fund; Special Climate Change Fund (SCCF), Least Developed Countries Fund (LDCF), Strategic Priority on Adaptation (SPA), International Climate Initiative (ICI), Clean Technology Fund (CTF), Adaptation Fund. A brief description of each included fund is given below, taken directly from the Climate Funds Update webpage:

GEF Trust Fund

The GEF Trust Fund is the common funding resource of the Global Environment Facility (GEF). Climate Change is one of the six focal areas supported by the GEF Trust Fund. The objective of this part of the fund is to help developing countries and economies in transition to contribute to the overall objective of the United Nations Framework Convention on Climate Change (UNFCCC). The projects support measures that minimize climate change damage by reducing the risk, or the adverse effects, of climate change. The GEF Trust fund was established in 1994. The total pledged is unknown as it is not possible to disaggregate the funds pledged for the climate change focal area from those pledged for other focal areas. [Check]

Special Climate Change Fund

The Special Climate Change Fund (SCCF) was created in 2001 to address the special needs of developing countries under the UNFCCC. The overall objective of the fund is to implement long-term adaptation measures that increase the resilience of national development sectors to the impacts of climate change. The SCCF should serve as a catalyst to leverage additional resources from bilateral and other multilateral sources. The Parties to the Climate Convention identified adaptation to climate change as the top priority of the SCCF, and that technology transfer and its associated capacity building activities as another essential area for funding. The Fund became operational in 2002. As of May 31, 2010, the total amount deposited is USD eq. 147.78 million

Least Developed Countries Fund

The Least Developed Countries Fund (LDCF) is managed by the Global Environment Facility (GEF) and aims to address the special needs of the Least Developed Countries (LDCs), which are especially vulnerable to the adverse impacts of climate change. This includes preparing and implementing National Adaptation Programmes of Action (NAPAs). The Fund became operational in 2002. As of May 31, 2010, the total pledged is USD eq. 221.46 million.

Strategic Priority on Adaptation

The Strategic Priority on Adaptation (SPA) was a 3-year pilot programme aimed to show how adaptation planning and assessment could be practically translated into full-scale projects. The SPA overall objective is to address local adaptation needs and generate global environmental benefits in the focal areas in which the GEF works: biodiversity, climate change, international waters, land degradation, and persistent organic pollutants. The Fund was made operational in 2004. \$50 million was deposited via the GEF Trust Fund.

The International Climate Initiative

The International Climate Initiative (ICI) is an innovative, international mechanism for financing climate protection projects run by the German government. It receives funding from the sale of tradable emission certificates. The overall objective of the fund is to provide financial support to international projects supporting climate change mitigation, adaptation and biodiversity projects with climate relevance. The ICI will mobilise resources from private companies (compliance buyers) under the framework of the European Union Emission Trading Scheme (EU ETS). In 2008, the German government auctioned 8.8% of its allowable emission permits to businesses. Approximately 30% of the revenue earned from this sale is intended to finance climate change-related projects. This is expected to amount to EUR400 million (USD618.30 million)/year for domestic and international use. EUR120 million (USD185 million)/year is earmarked for developing countries and countries in transition. Of this, half is intended for sustainable energy projects and the other half for adaptation to climate change impacts and biodiversity projects. The ICI will support mitigation (mainly sustainable energy systems), adaptation and preservation and sustainable use of natural carbon sinks/ REDD.

Clean Technology Fund

The Clean Technology Fund (CTF) is one of the two (along with the Strategic Climate Fund) multi-donor Trust Funds within the Climate Investment Funds (CIFs). The CIFs have been designed to support low-carbon and climate-resilient development through scaled-up financing channelled through the African Development Bank, Asian Development Bank, European Bank for Reconstruction and Development, Inter-American Development Bank, and World Bank Group. The CTF aims to support the rapid deployment of low-carbon technologies on a significant scale, with the objective of cost-effective reductions in the growth of greenhouse gas emissions. The Fund became operational in 2008. The total amount pledged by eight countries to the CTF is USD eq. 4.4 billion as of October 2010.

Adaptation Fund

The Adaptation Fund is a financial instrument under the UNFCCC and its Kyoto Protocol (KP) and has been established to finance concrete adaptation projects and programs in developing countries that are Parties to the KP in an effort to reduce the adverse effects of climate change facing communities, countries and sectors. The Fund is to be financed with a share of proceeds from clean development mechanism (CDM) project activities as well as through voluntary pledge of donor governments. The share of proceeds from the CDM amounts to 2% of certified emission reductions (CERs) that are issued for a CDM project activity. The Fund became operational in 2009. USD 3.287 million has been deposited in the Fund to date.

The justification for exclusion of the other funds is as follows:

The Hatoyama Initiative (HI) (the largest climate fund) has not been included as there is no publicly available data on the fund's projects. US\$15 billion has been pledged to the HI by the Japanese government (of which US\$5.3 billion had been assigned to projects as at July 2010 (ClimateFundsUpdate, 2010)), while the total amount pledged to the seven funds included in this analysis is (very) approximately US\$3.5 billion. The exclusion of the HI is therefore unfortunate, but cannot be avoided.

Several funds were excluded because they do not support infrastructure activities. These include the forestry funds (such as the Amazon Fund and Congo Basin Forest Fund). Two other funds also come under this category - the Global Climate Change Alliance (European Commission), which is a small fund principally focused on promoting dialog between European and developing countries, and the MDG achievement fund (UNDP), which is principally focused on supporting mainstreaming of climate change into policy, and general capacity-building. Both funds are relatively small.

The Global Energy Efficiency and Renewable Energy Fund (GEEREF) is a European Commission aiming to leverage private sector investment in green energy. The fund was not included because no funds have yet been disbursed.

The Strategic Climate Fund is one of the two (along with the Clean Technology Fund) multi-donor Trust Funds within the Climate Investment Funds (CIFs). The SCF is an umbrella vehicle for the receipt of donor funds and disbursements to specific funds and

programmes aimed at piloting new development approaches or scaling up activities aimed a specific climate change challenge or sectoral response. There are three funds under the SCF framework: the Pilot Program for Climate Resilience (PPCR), the Forest Investment Program (FIP) and the Scaling Up Renewable Energy in Low Income Countries Program (SREP). These programmes have not been included in the analysis for the following reasons: (1) The Pilot Programme for Climate Resilience has implemented just three pilot programmes, all focused on Technical Assistance for areas that are not directly relevant to this study; (2) Forest Investment Programme – forestry, therefore not relevant to this study; (3) Scaling Up Renewable Energy Program – no projects implemented as yet.

B.1.2 Gathering Information on Funded Projects

The information on projects was then extracted from the funds' individual websites (during September 2010), as they provided greater detail on individual projects than Climate Funds Update. In addition, Climate Funds Update includes projects from GEF funding rounds 4 & 5 only (covering the period 2006 – present) whereas the GEF website provides information on all historic projects (from 1994 when the GEF Trust Fund was established). All websites give information the approval status of projects, and only projects that have been approved were included. The websites used are as follows:

The Least Developed Countries Fund, the Special Climate Change Fund and the Strategic Priority on Adaptation are administrated by GEF and detailed project information for each of them is available on the GEF website:

<http://www.gefonline.org/>.

International Climate Initiative: http://www.bmu-klimaschutzinitiative.de/en/projects_and_programmes (Programme costs are given in Euros. An exchange rate of €1=1.25\$ has been used).

Clean Technology Fund: http://www.climateinvestmentfunds.org/cif/current_information_documents

Adaptation Fund: <http://adaptation-fund.org/fundedprojects> (Note that the Adaptation Fund has approved only one project to date as at November 2010)

B.1.3 Classifying and categorising projects

The project data was downloaded and collated in Excel. Thereafter, projects not relating to infrastructure were removed (using the definition of infrastructure given in the introduction to this report). Waste related projects have not been considered to be infrastructure and are therefore not included in this analysis.

The projects were then separated into mitigation and adaptation focus, according to the definitions of adaptation and mitigation given by the IPCC (see Box 1 in the main text).

The mitigation infrastructure projects were divided into the following sectors and sub sectors:

- Buildings
 - Capacity
 - Energy efficiency
- Energy efficiency
 - Demand side
 - Supply side
 - Supply and demand side
 - Capacity
 - Investment support
- Energy production
 - Renewable energy
 - Capacity
 - Investment support

- Other -
- Industry
 - Energy efficiency
 - Capacity
- Transportation
 - Urban transportation management
 - Urban transportation infrastructure
 - Road vehicles
 - Other

The adaptation projects were put into the following sectors:

- Capacity
- Water management
- Coastal zone protection

If a project had minor components that could be classified in different sectors, the major component decided the project sector classification. A very few projects covered several infrastructure sectors and were therefore impossible to categorise, and were excluded. Projects aiming to promote the adoption of certain technologies are classified as capacity building. The sub-category 'capacity' indicates a project that is close to 100% capacity-building. Many of the other projects have a capacity-building element. Biofuels have been classified as renewable energy, while it is acknowledged that they should only be certified as such if they are sustainably sourced.

Under energy efficiency: supply side indicates improvements in the efficiency of energy production; demand side indicates improvements in the efficiency of the end use of energy. Projects classified as 'energy efficiency – demand side' are general demand-side projects – not specifically focused on buildings or industry. Nonetheless, it is likely that a fair proportion of the investment in these demand side projects will be allocated to improving energy efficiency in buildings and industry.

Thereafter the countries were categorised according to geographical region and income level. The countries in the mitigation category were classified into Africa, Asia, Europe, Latin America and Oceania. The countries in the adaptation category were divided into Africa, Asia, Latin America and Small Island States. The United Nations Statistics Division's classification of geographical regions and other groupings was used to classify the countries.

[<http://unstats.un.org/unsd/methods/m49/m49regin.htm>] A project that is defined as Global is conducted across several regions.

To classify the income levels of the countries the DAC classification for 2009 – 2010 was used

[<http://www.oecd.org/dataoecd/32/40/43540882.pdf>]

The data was then converted into graphs in Excel.

The analysis for the Climate Funds is for total project cost in USD, including co-financing. The quantity of co-financing varies from zero to very high (more than 10 times the amount contributed by the fund in some cases), and comes from a variety of sources including host country governments, the private sector, and other development financing agencies and donors.

No distinction is made between loans and grants.

B.2 National Adaptation Programmes of Action (NAPAs)

NAPAs are funded under the Least Developed Countries Fund. Therefore any approved projects should have been included in the Climate Funds analysis. However, very few NAPAs have been approved to date, and an analysis of the regions and sectors for which funding has been requested gives a valuable insight into Least Developed Country adaptation priorities.

The data was gathered from the NAPA Project Database [http://unfccc.int/national_reports/napa/items/2719.php Oct 2010], and was compiled manually into an Excel file. Projects that only included a small element of infrastructure or that did not provide information on costs were excluded. The projects were classified in the following sectors:

- Agricultural water supply
- Domestic water
- Agricultural and domestic water supply
- Water and sanitation
- Water management and supply – multiple objectives
- Coastal zone protection
- Riverine flood protection
- Renewable Energy
- Climate monitoring infrastructure
- Capacity
- Other

The category Other includes housing, relocation, agro-tourism, health and soil preservation. The countries were categorised according to the same rules as the Climate Funds projects.

B.3 Clean Development Mechanism (CDM)

The CDM data was taken from the UNEP Risoe Centre CDM Pipeline website: <http://cdmpipeline.org/>, which analyses data from the UNFCCC website: <http://cdm.unfccc.int/index.html>. The sectors have been adjusted slightly from the classifications used in the UNFCCC website to make them more easily comparable to the data analysis for the Climate Funds. An analysis of regional flows for infrastructure has not been carried out due to time and funding restrictions. However, a discussion of regional flows from the CDM is provided in section 4.1.1. Approximately 80% of the CDM projects fit within the definition of infrastructure provided here, so this discussion will be directly relevant to the infrastructure sector.

Annex C: Low Carbon Growth Strategy Country Case Studies

Bangladesh		
Context	Progress to date	Climate change infrastructure policy
<p>Bangladesh is a Least developed country. It is highly vulnerable to climate change impacts due to its low-lying landmass, exposure to storms and floods, and economic reliance on agriculture which is vulnerable to flooding.</p> <p>Climate change impacts will affect the poorest sector of the population, including rural subsistence farmers and commercial farmers who depend on their agricultural output for an income.</p> <p>Bangladesh produced an estimated 0.38% of world GHG emissions in 2005 (CAIT, 2010). The main sources of emissions are the energy sector (62%) and land and forestry (32%), with agriculture only accounting for 5% of emissions, although it employs two thirds of the country's labour force.</p> <p>Bangladesh's climate change policy focus is on adaptation and disaster risk management.</p>	<p>Bangladesh's latest Poverty Reduction Strategy Paper (PRSP) identifies the need to integrate climate change into existing policies and strengthen programmes for resilience in agriculture and water management, disaster reduction, and health, with a focus on coastal areas.</p> <p>Low carbon growth strategies are in the early stages of development and much of the Government's 10-year climate change strategy focuses on strengthening institutional capacity, awareness building and education, mainstreaming of climate change policies in national and sector development programmes and coordinating policies between ministries.</p> <p>The 2005 NAPA and the 2008 Bangladesh Climate Change Strategy and Action Plan (BCCSAP) benefited from a wide range of consultations, including contributions from various levels of government, scientists, academics, different ethnic groups, NGO representatives, groups representing indigenous women and representatives of the private sector.</p>	<p>Bangladesh's climate change infrastructure policy identifies three priorities: (1) repair and rehabilitate all existing coastal embankments, river embankments and drainage systems and ensure effective operation and maintenance systems; (2) plan, design and construct dedicated adaptation infrastructure including cyclone shelters, coastal and river embankments and water management systems, urban drainage systems, river erosion control works and flood shelters; (3) undertake strategic planning of future infrastructure needs, taking into account the likely future patterns of urbanisation and socio-economic development and the changing hydrology of the country.</p> <p>Investment to date has also included flood protection of the road transport network and the development of an early warning system for natural disasters (ADB, 2009).</p> <p>Mitigation does not take a prominent place in the strategy, although one project is mentioned in the available documentation - an electricity generation project based on the collection of methane produced by urban waste.</p>
Brazil		
Context	Progress to date	Climate change infrastructure policy
<p>Brazil's economy is largely based around the service sector, although industry and agriculture also play an important role.</p>	<p>The Brazilian National Plan on Climate Change (NPCC) was launched in 2008, with most interim targets set between 2018 and 2020. It sets out specific programmes for low carbon growth as well as mainstreaming climate change</p>	<p>Brazilian low carbon growth infrastructure investments focus on three strategies in the energy sector: increased production of energy from biofuels (mainly ethanol and sugar can bagasse), an improved electricity distribution system (particularly</p>

<p>Brazil produced an estimated 2.7% of world GHG emissions in 2005 – over 1 billion tonnes (CAIT, 2010), a significant proportion of which is due to deforestation. Brazil produces 45.8% of its energy through renewable sources.</p> <p>Brazil is actively seeking to harness low carbon development to enhance competitiveness and open new markets, particularly for bioethanol, which provides about 40% of the automotive fuel in the country. It also recognises that low carbon growth opportunities are in line with its social development and poverty reduction objectives.</p>	<p>into public policy.</p> <p>NPCC targets will be met by promoting sustainable development in the industrial and agricultural sectors, maintaining a high proportion of renewable energy in electricity production, encouraging the use of biofuels in the transportation sector, and reducing deforestation.</p> <p>Civil society groups were invited to provide feedback on Brazil's National plan on Climate Change, but have since protested that their input was not taken into account by the Brazilian government.</p>	<p>reducing non-technical losses in the grid) and increased hydroelectricity production. More than 7,000 MW of renewable sources is scheduled to be brought on-line by 2010, stimulated by the Programme of Incentives for Alternative Sources of Electric Energy – PROINFA.</p> <p>In the transportation sector, Brazil's policy is centred on renewable vehicle fuels. Early investments in sugar-cane based ethanol has made Brazil the world's most efficient ethanol-producer, with ethanol providing about 40% of the automotive fuel in the country.</p>
<p>China</p>		
<p>Context</p>	<p>Progress to date</p>	<p>Climate change infrastructure policy</p>
<p>Industry and manufacturing are the most important sectors of the Chinese economy. They are also highly polluting. Increasing the efficiency of these sectors is critical to meeting mitigation targets.</p> <p>China was the top emitter of GHGs in 2005, producing an estimated 19% of world emissions, or 7.2 billion tonnes (CAIT, 2010). Emissions are mainly attributed to energy production (39%) and industry (33%), as well as agriculture (14%), the service sector (7%) and the transport sector (5%). Energy is mainly sourced from coal (accounting for 80% of all energy produced within the country) and hydroelectric power (15%).</p>	<p>China's 11th Five-year Plan for National Economic and Social Development (2006-2010) places great emphasis on building an energy-conserving and environmentally-friendly society. The government aims to restructure the economy by promoting low consumption industry and investments in high tech and service sector enterprises, with the dual aim of lowering emissions and enhancing global competitiveness. The strategy incorporates strengthened regulation, new green laws, market mechanisms and the dissemination of climate information through modern communication systems.</p> <p>China has been one of the biggest recipients of funds under the Clean Development Mechanism, especially for large energy related industrial projects. The government has a strong investment programme in R&D for green technologies.</p>	<p>The principal focus of China's climate change infrastructure policy is on energy generation – specifically lowering carbon emissions and increasing efficiency. There are additional measures for transportation.</p> <p>By 2005 hydroelectric power accounted for 23% of power generation capacity in China, and the sector continues to expand rapidly. Sixty wind farms have been constructed, and the sector has been boosted through laws that require that 70% of wind powered technology be produced internally, as well as offering tax breaks and tax havens to firms producing wind powered technologies.</p> <p>Over 1500 large and medium scale biogas digesters have been constructed, and the government is supporting decentralised biomass energy production plants. Solar, geothermal and tidal energy production programmes are also underway. China is</p>

	<p>There is no information provided in the Chinese plan as to the extent, if any, of civil society or private sector consultation aimed at informing China's climate change strategy.</p>	<p>already the world's largest producer of photovoltaic cells; its market share could grow considerably as global demand for alternative energy sources increases.</p> <p>China is developing its capacity for energy generation from nuclear power, and participating in experiments on nuclear fusion as a source of energy.</p> <p>In the transportation sector, China is aiming to develop electrified railways and improve the efficiency of planes and ships.</p>
Ethiopia		
Context	Progress to date	Climate change infrastructure policy
<p>Ethiopia's economy is based around agricultural production, which accounts for nearly 50% of GDP and employs around 85% of the national labour force. Services and industry also play an important role.</p> <p>Ethiopia produced just 0.2% of global GHG emissions in 2005 (CAIT, 2010). Around 80% of emissions are attributed to agriculture.</p> <p>Ethiopia is currently an oil importer, but has abundant potential for renewable energy production – particularly hydro, but also solar, wind, biomass and geothermal.</p> <p>Ethiopia is highly vulnerable to drought, and is projected to become more drought-prone due to climate change. Adaptation measures to combat drought are therefore a priority for the government.</p>	<p>In its Initial National Communication to the UNFCCC, Ethiopia has clearly stated a position adopted by many developing countries; that climate change mitigation and adaptation objectives should be combined with development objectives.</p> <p>Ethiopia does not have an explicit plan for mitigation, but published its National Adaptation Programme of Action (NAPA) in 2007. Projects include enhanced food security through management of water resources, irrigation systems in arid areas, and early warning systems for floods and droughts. The NAPA was drafted with the aid of a steering committee made up of 10 different government ministry and agency representatives and was also informed by a number of NGOs and universities.</p> <p>The government of Ethiopia is aiming to identify and develop potential CDM projects, particularly in the agriculture sector, in order to obtain funds for nationally</p>	<p>The Ethiopian government is seeking to develop renewable energy projects that would supply energy to both Ethiopia and its neighbouring countries, thus generating much-needed revenue. The 'Gibe III' dam, due to be completed in 2012, will be one of Africa's largest hydropower dams. Expansion of internal production of bioethanol and biodiesel is also planned, with anticipated developmental benefits including improved agricultural production, employment generation and improved energy security. The government is promoting energy efficiency and conservation projects, and utilising blended ethanol (E5) in the Addis Ababa transport system.</p> <p>Since most households rely on biomass sources for their energy and cooking needs, the government of Ethiopia is promoting efficient bio-energy as one of its main strategies. The Initial National Communication highlights the need to expand improved cook stoves.</p>

	appropriate mitigation initiatives. Ethiopia is supportive of a reformed CDM that expands programmes of activities and provides special incentives for small-scale projects.	
Guyana		
Context	Progress to date	Climate change infrastructure policy
<p>The majority of Guyana's population lives on a coastal strip of land, which is 1.4 meters below sea level. Addressing the risk of flooding is seen as a priority by the government of Guyana, which estimates that by 2030, the potential annual losses due to flooding could be around 10% of GDP.</p> <p>Guyana is a "net sink" for CO2 emissions, mainly due to the high proportion of forested land. Agriculture and energy are the main sources of emissions.</p>	<p>Guyana's 2010 Low Carbon Development Strategy is seen as one of the most comprehensive and ambitious plans to be prepared by a developing country. It outlines a model for the creation of a low-deforestation, low-carbon, climate-resilient economy. Guyana is aiming to benefit from proposals to integrate forestry into international mitigation strategies, whereby developing countries will receive financial incentives to reduce emissions from deforestation and forest degradation (REDD). This would depend on further development of REDD by the international community (particularly its adoption post-2012), which is by no means guaranteed as yet. Guyana plans to use REDD payments as the basis for funding its low carbon growth investments in renewable forms of energy, and climate change adaptation programmes such as flood defence.</p> <p>The government of Guyana has carried out extensive consultation with various Amerindian groups. Consultation has also been carried out with ministry representatives, stakeholders in the mining and forestry sectors and private sector organisations, and local and international NGOs.</p>	<p>Guyana has identified more than US\$1 billion in essential infrastructure investment that can be fully or partially funded through REDD, should it be implemented post-2012.</p> <p>Guyana currently relies on expensive and carbon-intensive imports for its electricity generation. It has completed designs for a single hydropower dam that could meet the needs of the whole country for the foreseeable future.</p> <p>The estimated short-term costs of adaptation infrastructure are projected to be above US\$1 billion. Priorities include upgrading of infrastructure and assets to protect against flooding, include the upgrading of drainage systems and the improvement of an ocean seawall protecting low lying coastal areas.</p> <p>Guyana's government also intends to adjust the country's building codes to account for climatic change, and enhance its early warning systems.</p>
Mexico		
Context	Progress to date	Climate change infrastructure policy
<p>The service and industry sectors are prominent in Mexico's economy. Mexico produced an estimated 1.7% of world GHG emissions in 2005 (CAIT, 2010). Energy production is</p>	<p>The Mexican low carbon growth strategy ties directly to its National Development Plan (2007 – 2012) which explicitly includes climate change as one of its action points. The</p>	<p>Carbon mitigation in the infrastructure sector focuses on changes in energy supply and production, transportation, and incentivising greener manufacturing processes.</p>

<p>the greatest source of emissions within the country (28% of total emissions), followed by the transport sector (20%) and agriculture (18%). Mexico has large domestic deposits of oil and natural gas. It is an oil exporter.</p> <p>The Mexican government is hoping to benefit from REDD payments to finance its low carbon growth strategy by introducing a scheme to replant forests on under-utilised agricultural land. 45% of Mexico's original forests have been erased since the 1950s (Chandler et al., 2002).</p>	<p>"Special Climate Change Program" (2008), combined with the National Climate Change Strategy of 2007, sets out a number of carbon abatement and green growth initiatives and projects. The central target is to reduce carbon emissions by 50% by 2050 (based on 2000 levels), and to reduce CO2 emissions to 2.8 tonnes per capita by the same date.</p> <p>Mexico has received US\$500 million financing from the World Bank Clean Technology Fund, and will also source funding from development partners and domestic sources. The government also aims to introduce a national carbon trading scheme by 2012.</p> <p>Consultations have occurred between different relevant ministries in the Mexican government in order to harmonise the objectives of each ministry in relation to the low carbon strategy. There is no mention of public consultation on the plan nor of any civil society involvement in its creation.</p>	<p>In the energy sector, renewable sources are being prioritised in order to meet targets, including solar energy, biofuels and hydropower, although carbon capture and storage and nuclear power are also under consideration. Various measures are proposed to improve gas energy efficiency, including reducing gas leaks and improving the gas distribution infrastructure.</p> <p>Investments will be made in transport infrastructure and cleaner vehicles in order to reduce the use of fossil fuels and increase the use of public transport. Transport infrastructure will be modernized to make road transport more energy efficient (and improve connectivity). Public transport and state owned vehicles will be replaced with more modern, energy efficient low carbon vehicles. The rail network will be modernized in order to introduce energy efficient trains.</p>
Nigeria		
Context	Progress to date	Climate change infrastructure policy
<p>Nigeria is the most populous country in Africa, and one of the continent's largest economies. The production and export of petroleum is one of Nigeria's main sources of income. Nigeria produced 0.8% of global GHG emissions in 2005 (CAIT, 201). Most of the CO2 emissions in the country come from the transport sector (36%) and the manufacturing sector (22%). The majority of electricity produced in Nigeria is produced by gas powered electricity plants (58%), followed by hydroelectric power (33%) and by oil fuelled power plants (9%). Nigeria is placing a lot of emphasis on improving the efficiency of gas powered</p>	<p>The Nigerian government is developing an initiative named 'Vision 2020' which aims to set the country on a low carbon growth development path. The strategy recommends that fiscal packages be provided in order to promote private investment in renewable energy sources such as wind farms, hydroelectric power, solar power and biomass. These incentives would include import exemption duties, tax holidays and investment grants. Both nation and foreign investors would be eligible in order to promote foreign investment in green technology within the country.</p>	<p>Even though Nigeria's main sources of energy are derived from fossil fuels (and will likely remain so by 2020), the government considers the development of renewable energy sources as important for reasons of national energy security. To this end the Nigerian government is intending to invest in R&D to develop renewable energy sources such as hydroelectric power, wind farms and tidal energy facilities.</p> <p>Nigeria is planning to increase the amount of hydroelectricity produced by using all its viable hydroelectric power generation sources, especially in rural areas. The national coordinating</p>

<p>energy production facilities as well as a reduction in carbon and greenhouse emissions produced as a result of gas flares, which are a major source of pollution within the country.</p> <p>Nigeria is highly vulnerable to climate change impacts, particularly flooding and desertification, making mitigation more relevant to policy-makers. The government of Nigeria also sees the green growth market as a potentially viable economic development sector.</p>	<p>There is no mention of a public or private consultation in Nigeria's low carbon growth strategy, but this is unsurprising given its early stage of development.</p>	<p>agency for alternative energy development has been established in order to promote this strategy, as well as promoting energy microgeneration in rural areas.</p> <p>The government also sees the development of nuclear power plants as a viable alternative to full reliance on fossil fuels.</p>
<p>Malawi</p>		
<p>Context</p>	<p>Progress to date</p>	<p>Climate change infrastructure policy</p>
<p>Malawi is a small net emitter of GHG. Last estimates for annual per capita emissions were in the region of 3.0 tonnes of CO₂e. The greatest contribution of emissions arises from the land use change and the forestry sector (99.7%) and industrial processes (0.3%). The domestic energy system is dominated by biomass.</p>	<p>Malawi's 1994 National Environment Action Plan (NEAP), its Vision 2020 launched in 1998 and its 2002 PRSP outline measures and priorities to promote sustainable use of the environment, including the following priority development pillars: rapid sustainable pro-poor economic growth and structural transformation; human capital development; improving the quality of life of the most vulnerable; and good governance. The NAPA, developed by the Ministry of Lands and Natural Resources, built on these priorities by providing concrete measures to cope with the impacts of climate change. It prioritises the creation of buffers for the most vulnerable from the socioeconomic effects of climate shocks.</p> <p>The market-based mitigation options considered in the National Communication include energy pricing, fiscal incentives, regulation and demand-side management. The submission also recommends the removal of duty and sur-taxes on renewable energy technologies. Mitigation options in its 2002 communication to the UNFCCC did not include alternatives to petrol and diesel for transport. Lack of</p>	<p>Malawi's energy resources include biomass, coal, hydropower, solar and wind. The government has established a National Sustainable and Renewable Energy Programme (NSREP) to increase access to and coordinate implementation of renewable energy technologies. To this end, Malawi's Initial National Communication to the UNFCCC targets the following mitigation options in agriculture, energy and forestry:</p> <ol style="list-style-type: none"> 1. Use of briquettes instead of firewood; 2. Improved mud and ceramic stoves; 3. Use of biogas for lighting and cooking; 4. Rural electrification through grid extension, mini/micro hydropower and solar photovoltaic heaters and cookers which would reduce demand for biomass energy; 5. Increased use of public transport and catalytic converters to reduce GHG emissions; 6. Wind water pumping instead of diesel and petrol engines; 7. Promote re-vegetation and natural regeneration, forest

	funding continues to be a fundamental barrier to implementation of these programmes.	protection and agro-forestry; 8. Improved nutrient management in livestock and rice fields and better water management.
Rwanda		
Context	Progress to date	Climate change infrastructure policy
Rwanda's largest source of CO ₂ e emissions is the energy sector (mostly from methane), followed by agriculture, according to 2002 data in its Initial National Communication to the UNFCCC. It has negative net CO ₂ emissions owing to the sequestration capacity of its forests. Rwanda has demonstrated commitment to low carbon energy growth, with a focus on the development of indigenous and renewable energies.	The government has defined policies and measures in its national submission to the UNFCCC to encourage low carbon development in energy, forestry, agriculture and waste. Rwanda has identified various tools needed to achieve expected results including training, education, tax exemption, low interest loans and other financial incentives. Rwanda has stressed that it is critical for the country to receive financial support from developed countries and international institutions beyond conventional forms of aid to support its goals to transform the energy sector. It sees supporting the energy sector in developing countries as an investment opportunity for energy companies, as it can create employment and will encourage the sector to pursue sustainable development following a low carbon path.	Rwanda is working to increase access to electricity under its sector-wide approach, which aims to increase access to electricity from 6% of the population to at least 35% by 2020. Access in rural and off-grid areas will be supported by solar and micro-hydro power solutions. Rwanda also has a model methane project at Lake Kivu, which extracts methane to produce electricity which could potentially be exported. Additional infrastructure-related measures in Rwanda's submission to the UNFCCC include: Energy: <ul style="list-style-type: none"> • Promote and extend use of biogas, solar photovoltaic, solar water heaters and micro-hydro • Intensify regional collaboration in electricity generation and integration of supply network and promote energy commerce at regional level • Promote power generation from waste and algae in small-scale industries • Promote low consumption lamps and efficient cooking stoves • Introduce efficient wood charcoal-making technologies Waste and waste disposal: <ul style="list-style-type: none"> • Banning wastewater flows on public roads and areas

		<ul style="list-style-type: none">• Banning use of cesspools for disposal of residuary urban waters• Imposition of a water treatment tax• Extension of lagoon purification technology
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**ENGINEERS
AGAINST
POVERTY**

2nd Floor, Weston House
246 High Holborn
London, WC1V 7EX
United Kingdom

Tel +44 (0)20 3206 0488

Fax +44 (0)20 3206 0490

Email info@engineersagainstopoverty.org

www.engineersagainstopoverty.org



111 Westminster Bridge Road
London SE1 7JD
United Kingdom
Tel +44 (0)20 7922 0300
Fax +44 (0)20 7922 0399
Email info@odi.org.uk
www.odi.org.uk

Author contacts:

Lily Ryan-Collins: l.ryancollins@engineersagainstopoverty.org

Karen Ellis: k.ellis@odi.org.uk

Alberto Lemma: a.lemma@odi.org.uk