

Low-Carbon Development for the Least Developed Countries

Alex Bowen and Sam Fankhauser

Introduction

The threat that human-induced climate change poses to many of the least developed countries (LDCs) is profound. Greater dependence on rain-fed agriculture and forestry as sources of employment and income makes many of them more vulnerable to climatic changes and variability. Many LDCs are already subject to climatic stress because of their location in the Tropics and other areas subject to a high incidence of weather-related shocks – storms, drought, flooding and extremes of temperature – and to high temperatures. In poor countries, but not middle-income or rich ones, higher temperatures are correlated with lower subsequent growth of GDP per capita (see Dell, Jones & Olken 2008).¹ High temperatures can raise mortality in rural areas sharply by reducing agricultural incomes. Low incomes have made it more difficult to recover from past weather-related challenges and to prepare for future disasters. Many poor countries have been caught in a poverty trap due at least in part to weather-related disasters, with the high frequency of shocks eroding social and physical capital.

Climate change – entailing rising global mean temperatures and major alterations in precipitation, and increases in the incidence of storms, floods

¹ Jones and Olken (2010) also find that high temperatures in poor countries have an adverse effect on their exports, especially agricultural and light manufacturing exports.



Alex Bowen is a Principal Research Fellow at the Grantham Research Institute on Climate Change and the Environment at the London School of Economics.



Sam Fankhauser is Deputy Director of the Grantham Research Institute at LSE and a Director at consultancy Vivid Economics.

and drought – is likely to exacerbate these problems. In consequence, LDCs need an international agreement on climate change that involves all countries with substantial emissions, including some emerging countries like India and China with large numbers of people still in poverty.

Why should a global deal mean that smaller and less developed countries, especially those already having difficulty sustaining per capita income growth, adopt low-carbon development strategies? The contribution of LDCs to the greenhouse gas problem is very small. LDCs accounted for just over 4% of global greenhouse gas (GHG) emissions in 2005 and only 0.3% of cumulative carbon dioxide emissions from energy (World Resources Institute 2010).² Despite this we argue that LDCs should follow low-carbon development paths appropriate to their development needs – if certain conditions are satisfied. Why? First, tackling many of the market and government failures that stand in the way of low-carbon development would enhance productivity and well-being in LDCs themselves. Second, if a global deal is eventually achieved, progress will be redirected towards low-carbon technology. For LDCs to share in growth from this source, their growth will have to be ‘green’ too. Third, LDCs offer the world some relatively cheap options for reducing emissions, particularly from agriculture, land use change and deforestation. There are efficiency grounds encouraging LDCs to exploit these options to minimise the global costs of decarbonisation.

However, the global costs of decarbonisation should be shared equitably with the condition that, where reducing greenhouse gas emissions in LDCs entails costs, poor people should not bear these costs. Rich people should pay towards LDC mitigation burdens, on top of any assistance to help LDCs deal with the impacts of climate change.

Climate change mitigation, adaptation and development

Economic growth has been associated with increases in energy use and energy-related emissions per head. There has been a strong correlation over time between increases in GDP and increases in energy usage and CO₂ emissions, a relationship that is stronger among lower-income countries (Bowen *et al.* 2009). The energy intensity of GDP is broadly similar

² Cumulative data are for the period 1850 to 2006.

for LDCs and the world as a whole, although world GDP per head is about eight times average LDC GDP per head. However, LDCs' energy usage is less carbon intensive on average. Excluding land use change, LDCs' average CO₂ emissions intensity of GDP was 195 tonnes per million dollars of GDP in 2005, compared with an average of 487 tonnes for the world as a whole.

The need for 'headroom' in carbon use for LDCs to grow and overcome poverty is seen in the Kyoto Protocol where poor countries need not adopt emission reduction targets. Rapidly industrialising countries have been much more emissions intensive than typical LDCs. The corresponding figures for India and China were 505 and 1,052 tonnes per million dollars of GDP respectively. If all

poorer countries were to move up towards these levels of emission intensity as their economies grew, keeping global warming to 2°C or less would be an unobtainable objective. If China and India are to play their part in

The energy intensity of GDP is broadly similar for LDCs and the world as a whole, although world GDP per head is about eight times average LDC GDP per head.

global emissions control, and LDCs are to follow them in achieving sustained economic growth and poverty reduction, the challenge is ultimately to decouple emissions and output growth. The migration of more mature manufacturing industries to lower-income countries means it is also a challenge to decarbonise consumption of imports by rich countries.

The keys to decoupling are the malfunctions in economies that encourage greenhouse gas emissions. These emissions create an adverse externality in the likely damages flowing from climate change and the risks of even more catastrophic and irreversible climate outcomes. In the absence of carbon pricing, firms and households do not factor these damages and risks into their decisions.

There are other problems, such as bad governance and social conflicts, that also distort economies, inhibiting growth and stimulating greenhouse gas emissions and environmental degradation. The encouragement of land grabs by agro-forestry businesses, conflicts over fossil fuel resources and subsidies for middle-class energy consumption are three pertinent examples. An improved understanding of climate change increases the perceived costs of several of these malfunctions in economies and the

urgency of correcting them by improved collective decision making. This can generate significant benefits by raising output directly and enhancing longer-term growth potential. It can also improve the composition of output in economies, better reflecting the long-term costs and benefits of different activities and thus helping to make development more environmentally sustainable as well as enhancing the life chances of the poor.

Action to reduce emissions is also likely to generate other valuable co-benefits. For example, developing renewable energy sources can produce co-benefits such as reduced air pollution, greater energy security, reduced foreign exchange needs and an improved quality of life. The World Health Organization (WHO) estimates that 1.5 million premature deaths per year are directly attributable to indoor air pollution from the use of solid fuels, implying more than 4,000 deaths per day, more than half of them children under five years of age (World Bank 2010). More than 85% of these deaths (about 1.3 million) are due to biomass use, the rest due to coal. Indoor air pollution associated with biomass use is directly responsible for more deaths than malaria, almost as many as tuberculosis and almost half as many as HIV/AIDS. Aunun *et al.* (2007) estimated that, in China, reductions in CO₂ emissions of 10–20% could generate reductions in air pollution and other benefits that would more than offset the costs of action.

Another potential co-benefit is greater energy security. Developing renewable low-carbon energy sources is likely to provide more countries with indigenous energy supplies, reducing dependence on fossil-fuel imports and an inadequate grid infrastructure, giving them greater flexibility in energy supply. In several cases, the technologies involved are likely to be less capital intensive and more labour intensive (Fankhauser, Sehleier & Stern 2008).

Focusing on low-carbon growth will allow LDCs to benefit from the likely future bias in technological progress towards renewable energy technologies. Learning by doing, together with carbon pricing, is likely over time to induce significant cost reductions in renewable energy technologies compared with more mature hydrocarbon-based power. The worldwide search for better biofuels gives some LDCs scope for developing a new and valuable cash crop as well as a way of developing their own transport along low-carbon lines. However, such a development needs to be undertaken in the context of a comprehensive low-carbon growth strat-

egy, so that new biofuel cultivation does not lead to accelerated deforestation and loss of peatlands.

There are a number of reasons why it makes sense for LDCs to adopt low-carbon growth paths appropriate to their needs and capabilities immediately. First, to avoid 'locking in' high-carbon technologies in long-lived plant, equipment and infrastructure or, alternatively, premature scrapping when low-carbon policies were finally adopted. Second, it would be 'export friendly' in a world in which rich countries are likely to become more concerned about low-carbon consumption. Third, it would allow LDCs to benefit from any subsidies for low-carbon research, development and deployment deriving from future international agreements on intellectual property rights and make it more likely that funds would be directed towards technologies relevant to the industrial structure of LDCs (in particular, agriculture and land use).

Finally, it would facilitate an eventual global deal on climate change, with the agreements on carbon financing and other flows of funds to LDCs an important part of such a deal. These flows of funds should be additional to current pledges of Official Development Assistance (ODA), given that the expected costs of climate change mitigation and adaptation are considerably higher than was understood when developed countries first committed to raising ODA to 0.7% of gross national income. But additionality in this sense does not logically entail that the funds should all be earmarked for explicit climate-change policies. Some of the most effective policies against climate change may be policies with the proximate target of better governance and the correction of pervasive market failures.

The question of incremental development funding draws attention to one of the caveats about the benefits to LDCs of adopting appropriate low-carbon growth paths as soon as possible. Globally, climate-change mitigation is likely to entail resource costs (discussed further below), although these costs are likely to be much less than the benefits from avoided climate change, but costs will be front-loaded relative to benefits. Developed-country support for these costs needs to be in place before they are incurred. In some cases, effective support may be very difficult to organise, for example, because of the inadequacy of public-authority outreach in remote rural areas or of support mechanisms for the most poverty stricken.

A second caveat is that a major share of mitigation costs will be due to the adoption of low-carbon technologies before their marginal costs have been driven below those of fossil-fuel technologies. Early adoption by developed countries is warranted by the returns to learning by doing and to reversal of the bias towards innovation in currently cheaper technologies (Acemoglu *et al.* 2009). It is not so clear how much LDCs should share in the necessary R&D and experimentation. In many industry sectors, the comparative advantage in early-stage innovation and learning by doing lies with developed countries, and the challenge will be to ensure rapid technology diffusion once new technologies become cost-competitive. LDCs may be well advised to delay related capital investments until the relevant technologies have travelled down the learning curve (while avoiding locking in soon-to-be-obsolete carbon-intensive technologies). However, there are still likely to be activities that will benefit from innovation and experience being undertaken in LDCs (e.g. tropical forestry management, concentrated solar power). That may take longer to bring down costs, particularly if adequate technical assistance is difficult to deliver.

Third, many of the benefits from early action should flow from the correction of market failures. This depends on appropriate public policies being put in place, but greater public involvement risks the sort of rent-seeking and distortion of incentives identified by development economists such as Easterly and Collier (Easterly 2001; Collier 2008). The pace at which ‘low-hanging fruit’ can be harvested may be slower than in OECD countries, if improvements in governance and institution-building are required first.

Although research in this area is at an early stage, several efforts have been made to examine the practical scope for low-carbon development, particularly among some of the larger, more rapidly growing developing economies. Development agencies such as the World Bank and UK DFID have been promoting low-carbon growth studies and helping LDCs develop Nationally Appropriate Mitigation Action plans. These studies suggest that the theoretical arguments for low-carbon development are supported by empirical evidence. However, more work tailored to the particular circumstances of LDCs is needed. A counter-argument emphasises the need to encourage traditional development. Schelling (1997, 2007), for example, argues that it may not be fair to ask the poor to make large sacrifices on behalf of following generations, which are likely to be much

richer than they are. The focus should be on raising people out of poverty to make societies more resilient in the face of climate change impacts. Growth and changing industrial structure is the best form of adaptation. There are two problems with this argument, as Shalizi and Lecocq (2009) have pointed out. First, it does not take sufficient account of the benefits of accelerating mitigation actions globally, deriving from induced technical change and the option value of early global action. Second, it does not place enough weight on the risk that poor countries may stay poor if subjected to a higher incidence of climate-related disasters. We cannot be sure that developing economies will all converge towards the average levels of income per head of industrial countries; the evidence for the long-term convergence of average per capita incomes outside of the OECD and major emerging-market economies is not convincing, and a number of development economists have drawn attention to the poverty traps afflicting many LDCs despite receiving development aid (Collier 2008).

This has two implications. First, for a given distribution of income, there will be more people in absolute poverty for longer, so that the resilience of LDCs to climate change in the future will be exaggerated. Second, a lower discount rate for LDC investment projects, including in climate-change mitigation and adaptation, will be appropriate.

It is right, however, to stress that development is key to tackling poverty and making economies more climate-resilient. Richer, more diversified economies are better able to deal with weather-related shocks. Countries that have higher levels of socioeconomic development, as indicated by basic measures of factors such as literacy, health and quality of governance, are hit less hard by extreme weather-related events, and are better able to recover from the damages they do suffer. Richer households can afford to take a less risk-averse approach to innovation and adaptation to climate change. Despite the synergies between development and climate-change mitigation, there is a need for further research on the interactions among policies aimed at these two objectives and at promoting adaptation to climate change. Improving transport infrastructure, for example, is likely to be warranted on development grounds even though it encourages carbon emissions from vehicles. But carbon pricing and adaptation policies should influence the specific infrastructure choices made.

Low-cost options for greenhouse gas emission reductions in LDCs

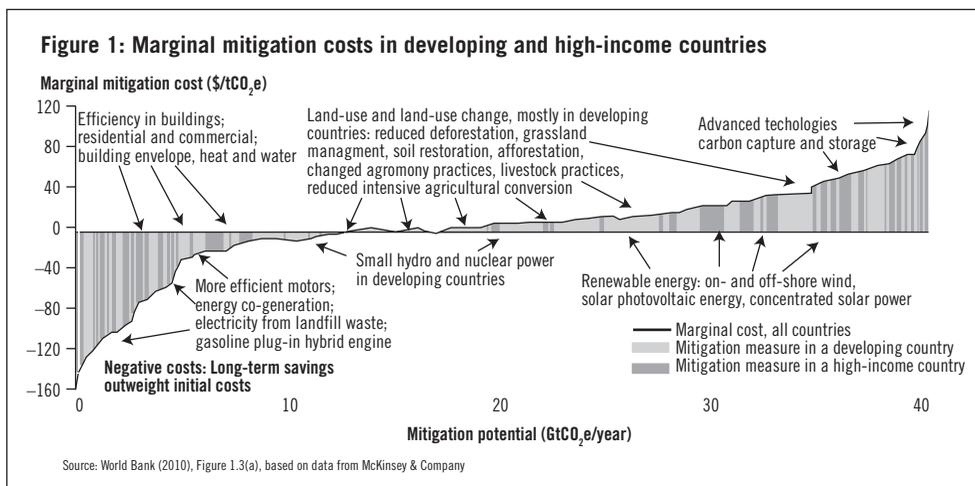
The costs of climate change mitigation globally are uncertain. Stern (2007) concluded that the expected annual cost of achieving emissions reductions consistent with stabilisation at around 500–550 ppm CO₂e were likely to be around 1% of GDP by 2050, within a range of +/- 3%. Policymakers have focused recently on the desirability of keeping the global temperature increase since pre-industrial times to 2°C or less, but subsequent analysis has focused on a more ambitious target of 450 ppm CO₂e or similar. Several large-scale modelling exercises have suggested that such a target is both feasible and not much more expensive. But other studies are more sceptical.³

It seems reasonable to conclude that climate-change mitigation is likely to involve costs overall, but that well-designed policies and incentives could bring these costs down substantially. Good policy entails implicit or explicit carbon pricing but also measures to tackle market and government failures, not least underinvestment in low-carbon technological development, especially in areas of greater relative importance for LDCs such as agricultural practices and forest management, where technical assistance from countries with stronger research capabilities is important.

Good policy design ensures that there is ‘what, where, when’ flexibility to keep costs down, with firms and public agencies able to choose which greenhouse gas emissions to cut, the geographical and industrial location of the cuts, and the timing of the cuts, subject to a credible and stable long-term climate-change policy framework. In the jargon of economists, minimising costs requires that the marginal costs of additional emissions reductions are the same wherever they take place.

Developing countries offer similar opportunities for zero- or negative-cost mitigation as do industrial countries, but more options at low cost, mainly in agriculture and forestry, as Figure 1 indicates. These estimates have to be treated with caution. They do not fully take into account the macroeconomic effects and relative price changes likely to be induced by ambitious climate-change policies; they may underestimate the costs of

³ The more optimistic reports include those of the ADAM and RECIPE projects (Hulme *et al.* 2009, and Edenhofer *et al.* 2009, respectively). The 22nd Stanford Energy Modeling Forum is more critical; see the special issue of *Energy Economics*, 31, 2, December 2009 (see Blanford, Richels & Rutherford 2009).



surmounting barriers preventing the take-up of negative-cost options; and they do not reflect the difficulties of financing investments for which the pay-offs arrive much later. They are consistent with the argument that the correction of market and policy failures can produce some cheap mitigation. The rank ordering of options assessed on a consistent basis is helpful for policymakers.

As far as the location of emission cuts is concerned, developing countries offer the world several low- or no-cost options for emissions reductions. The narrower group of LDCs offers somewhat less scope, given their low levels of energy- and industry-related emissions, but the opportunities in agriculture and forestry are substantial, especially relative to their levels of GDP.

This is good news for two reasons. First, it means that some mitigation in LDCs (for example, by improving forest management, introducing local solar power, and reducing the use of unmanaged traditional biomass for heating and cooking) could raise their productivity and employment while improving access to energy, providing an incentive for LDC authorities themselves to adopt low-carbon growth strategies. Second, it provides an incentive to industrial countries to pay for emissions reductions in LDCs, reducing their own mitigation costs while providing a stream of finance and technology for LDCs.

Such payments are essential if minimising the global costs of mitigation is to go hand in hand with an equitable distribution of those costs. The payments can be generated through agreements and mechanisms

such as the Clean Development Mechanism, Reduced Emissions from Deforestation and Forest Degradation, and the proposed Copenhagen Green Fund. Some of the burden to high-income countries will be carried in the form of higher prices for imports from developing countries of high-carbon-content products (which should be subject to carbon pricing or taxation in the developing countries themselves, so that they benefit from the resultant revenue) and their low-carbon replacements (which are likely to be more expensive initially than high-carbon ones, in the absence of carbon pricing).

A low-carbon development path for poor countries

The main development objective for LDCs remains the achievement, and subsequent consolidation, of the Millennium Development Goals, which UN member states adopted back in 2001. There has been considerable progress on poverty alleviation since then, but as the 2015 deadline for the MDGs approaches, it is clear that the performance in many areas is still badly off track.⁴ This is particularly the case for sub-Saharan Africa, and it is why the MDGs remain the top priority for low-income countries.

Climate change does not alter these fundamental objectives, but it may affect the way in which the MDGs are reached. The objective is no longer just development, but development that is low carbon and also resilient to climate change. The three challenges of poverty alleviation, emission abatement and climate change adaptation have to be considered together; there will be synergies but also trade-offs among them. In this section we try to give a sense of what ‘low-carbon development’ might mean in specific sectors and for particular development issues. The conclusions are generic, given the short length of this paper. Actual low-carbon development plans will have to be much more detailed and of course country-specific. They will have to take into account the particular socioeconomic circumstances of countries, and their approach to economic growth, employment, education, public health, social protection, energy security, trade and industrial development.

Many developing countries have already embarked on such plans – Brazil, China, India and South Africa are perhaps the most prominent

⁴ MDG progress is tracked on <http://mdgs.un.org/unsd/mdg/Default.aspx> (accessed on 1 May 2010).

examples. Unlike traditional development plans, they do not necessarily have the development needs of poor people at their centre and instead focus on identifying the cheapest emission reduction options from a cost curve. However, they show unequivocally the low-carbon challenge in poor countries is fundamentally different from that in rich countries. In high-income countries, decarbonisation is about changes to power generation, the redesign of electricity grids, cuts in industrial emissions, residential energy efficiency and new approaches to transport. Capital-intensive and technologically sophisticated options are available. In LDCs, the decarbonisation challenges are in land-use change, electrification, private-sector development and access to basic services such as the provision of heat, light and water, as these are where emissions would be most likely to rise initially in the event of high-carbon development. Labour is more plentiful relative to capital, and employment-creating opportunities are generally more valuable.

As low-income countries move beyond the MDGs, we will see the emergence of a middle class with different aspirations and consumption patterns. This will create pressure on emissions of the kind we already see in developed countries and increasingly in middle-income countries like China. But, for the poorest countries of the world, this point is a long way off; per capita incomes are lower, and the power, industry and transport sectors of their economies are less important. When they reach it, low-carbon technologies will, it is hoped, be more developed and widely available, allowing them to realise their development ambitions within the global carbon constraint.

In the meantime, the main link between climate change and development is through adaptation. Mitigation, especially in agriculture and land use, at least partly paid for by developed countries, and implicit or explicit carbon pricing to give the right long-term signals are desirable, but the balance between spending on mitigation and adaptation is likely to be much more skewed towards adaptation. Poor countries are more vulnerable to climate change not only because they are exposed to more severe impacts but because their institutional and socioeconomic capacity to adapt is insufficient (Barr, Fankhauser & Hamilton 2010).

Basic indicators of socioeconomic development – such as educational attainment, good healthcare, safe drinking water, access to credit and competent government institutions – are all associated with higher resilience

to and lower impacts from extreme weather events (World Bank 2010). Few, if any, aspects of this agenda are associated with excessive greenhouse gas emissions.

In contrast, *access to energy* is an obvious area of friction between development and carbon emissions. Worldwide, some 1.6 billion people still do not have access to electricity, and 2.6 billion rely on firewood for cooking (World Bank 2010). Although there is no MDG on energy, we know that access to modern forms of energy is central to development and poverty alleviation. Electricity is essential to provide basic services such as education, healthcare and safe drinking water, and for all entrepreneurial activity. The use of dirty fuels for cooking is also associated with respiratory disease and indoor air pollution, as we have seen above.

The World Bank estimates that providing modern sources of energy (predominantly from the primary use of fossil fuels) to everybody would add no more than 2% to global CO₂ emissions. It seems a small price to pay, compared with the huge development benefits. Electric energy today makes up only 5% of carbon emissions in low-income countries, compared with 38% in rich countries (World Bank 2010).

Moreover, bringing electricity to LDCs need not necessarily incur excessive carbon emissions. With rural electrification we know that, in remote areas with dispersed demand and low levels of consumption, renewable energy sources, such as solar PV, can compete with fossil fuel-based solutions such as diesel generators or the extension of the electricity grid (see e.g. IFC 2007). Where electricity grids exist, the key challenge often is to make them more reliable, reduce outages and cut distribution losses.

The World Bank estimates that providing modern sources of energy (predominantly from the primary use of fossil fuels) to everybody would add no more than 2% to global CO₂ emissions.

In other words, there is significant scope for energy efficiency improvements in low-income countries as well, by improving infrastructure investment and management – usually involving public spending and regulation.

However, the institutional challenges, capacity gaps and financial barriers to realise this potential are invariably large and will require effective assistance from the development community.

It is also clear that not all trade-offs can be avoided. There will be (potentially substantial) demand for increased power generation capacity in low-income countries, much of it probably from conventional hydrocarbon sources. The onus will be on rich countries to ensure that high-carbon power plants can in due course be retrofitted with carbon capture and storage technology – and to pay the associated extra cost.

Until energy demand picks up, the most important source of greenhouse gas emissions in low-income countries remains, by some distance, *land-use change and forestry*. Together it accounts for 50% of low-income-country emissions (World Bank 2010). Reducing emissions from deforestation and forest degradation is often seen as one of the cheapest options to halt global warming. Inclusive, sustainable forest management is also a crucial, pro-poor development measure. Reducing forest loss is one of the indicators for the Millennium Development Goals and a key priority of global development assistance. Forests are critical sources of income and well-being for many poor people. An estimated 735 million people live in or near tropical forests and depend on them for their livelihood. The link between poverty and deforestation is, however, complex (Chomitz 2007). Rich and poor people alike contribute to forest loss, and deforestation can both increase and reduce poverty levels.

Even more complex than the deforestation–poverty link are the social, economic and institutional factors that underlie deforestation. They include ill-defined property rights over forest assets, government capture by vested interest, large-scale corruption and, crucially, the undervaluation of ecosystem services. Forests create financial revenues as a source of food and timber, but not for the spiritual value, climate regulation and biodiversity services they also provide.

The single most important cause of forest loss, though, is agricultural expansion. High-value activities like palm oil production and cattle ranching can yield revenues in excess of \$3,000 per hectare (Grieg Gran 2008), much more than standing trees – unless their carbon and ecosystem value can be factored in and monetised.

This is why proposals to pay for reduced emissions from deforestation and forest degradation (REDD) under the emerging new global climate change regime are important. They might alter the economic balance between cutting trees down and leaving them standing. The renewed willingness to tackle deforestation and to fund this effort internationally

provides a unique opportunity to tackle this decade-old issue. However, the intricate nature of the problem and the deep political economy constraints should not be underestimated, particularly if REDD creates attractive new opportunities for rent seeking.

Pressure to increase agricultural output is also putting increased stress on ecosystem and forest resources. *Agriculture* contributes more than 20% to the gross domestic product of low-income countries and accounts for about the same amount of their greenhouse gas emissions (World Bank 2010). For many low-income families, it is their main source of income and subsistence. Although the share of agriculture in GDP will fall as nations grow richer and diversify, increasing agricultural productivity is an important development challenge going forward.

It is essential to meet development goals on malnutrition and cater for a growing world population of perhaps 9 billion in 2050. Unsurprisingly, UK DFID sees agricultural productivity as one of eight key factors that underpin economic growth in developing countries (DFID 2009).

The unprecedented increase in agricultural output and productivity needed over the coming decades may be at odds with the demands of a low-carbon economy. The green revolution of the 1960s and 1970s achieved its productivity boost largely on the back of mechanisation, irrigation and fertilisation – activities that could well increase the carbon footprint of agriculture. There is ample scope for productivity improvements through better farming practices and efficient management. Nevertheless, tackling agricultural emissions is an important challenge for low-carbon development, exacerbated potentially by a growing demand for biofuels and reduced agricultural yields as a result of climate change.

Transport and industry make up a much smaller share of overall greenhouse gas emissions, 11% of the total compared with 38% in high-income countries. Private-sector-led growth is a cornerstone of virtually all poverty reduction strategies, brought about by improvements in the business environment, better access to finance, support for SMEs and the promotion of foreign investment. A better transport, communications and trade infrastructure is another integral part of this general thrust. We should therefore expect (and accept) that emissions from these sectors will rise. The challenge is to ensure that economically efficient production practices and standards are adopted; that is likely to promote energy and carbon effi-

ciency too. There are industrial abatement opportunities in all countries, including low-income countries.

Despite suspicions of a ‘race to the bottom’, foreign investment can often be associated with more efficient production practices and the transfer of technologies. It may be more difficult to increase the environmental performance of small and medium-sized enterprises (SMEs), which contribute most to economic activity and provide the bulk of jobs in most countries. There is evidence that SMEs are often associated with inferior environmental performance (see Blackman 2006). For both small and large firms, targeted policy measures and financial incentives will be crucial, including appropriate energy tariffs and – particularly in the case of SMEs – access to finance and technical know-how.

Conclusion

The poorest countries of the world are greatly threatened by human-induced climate change. It is vital for them that the global community collectively acts to halt it. The new dangers make it all the more important that collective action takes into account their development needs. LDCs are likely to be hit earliest and hardest while having the least capacity for adaptation. The three major challenges – limiting climate change, adapting to its consequences and reducing poverty – have to be faced together. It also requires that LDCs follow a development path that differs from both those trodden by today’s industrial countries and those being explored by emerging-market economies at present. All this will require financial assistance from developed countries.

The most important source of greenhouse gas emissions in LDCs is land use change, in particular deforestation. Halting forest loss is also a development and local environmental issue and, as such, a key priority of low carbon development. Synergies between poverty alleviation and emission reduction also exist in rural electrification, where renewable energy solutions such as solar PV are often cost-competitive with fossil-fuel-based solutions. Elsewhere there may be trade-offs between development and low-carbon objectives – for example, when it comes to transport and industrial development. Good transport links and a thriving private sector are essential for growth and development. Emissions from these sources

may therefore increase, but it is important that the cleanest and most efficient technologies are deployed.

Moving on to such paths is likely to entail higher resource costs initially. On grounds of equity, those extra costs should be borne largely by today's rich countries and by future generations, who – if climate-change policies are successful – will be better off and subject to much less risk than they would have been otherwise. That is why it is important that international negotiations focus on the financing needs of the LDCs.

But low-carbon growth for LDCs need not be solely a story about extra costs in the short term, with the promise of more sustainable development in the long term. The threat of climate change has cast more light on the importance of key failures in markets and governance, and increases the urgency of tackling them – in LDCs as in other countries. The poorest countries can benefit immediately from a greater focus on this task – with a recognition of the need to correct underinvestment in appropriate technology development, a greater emphasis on resolving undefined or contested land rights, the provision of networks for the delivery of cleaner energy to the poor, and an appreciation of the co-benefits for health and the environment that could flow from low-carbon development strategies.

Acknowledgements

We are grateful to Oxfam GB for initiating this paper. We would also like to acknowledge support by the Grantham Foundation for the Protection of the Environment, as well as the Centre for Climate Change Economics and Policy, which is funded by the ESRC and Munich Re.

References

Acemoglu, D., P. Aghion, L. Bursztyn & D. Hemous (2009). *The Environment and Directed Technical Change*, NBER Working Paper Series 15451, Cambridge, MA: National Bureau of Economic Research.

Aunan, K., T. Berntsen, D. O'Connor, T. Hindman Persson, H. Vennemo & F. Zhai (2007) Benefits and costs to China of a climate policy. *Environment and Development Economics*, 12, 3 pp. 471–497.

- Barr, R., Fankhauser, S. & Hamilton, K. (2010) Adaptation investments: a resource allocation framework. *Mitigation and Adaptation Strategies for Global Change*, **15**, 8, pp. 843–858.
- Blackman, A. (ed.) (2006) *Small Firms and the Environment in Developing Countries*. Collective Impacts, Collective Action. Washington, DC: RFF Press.
- Blanford, G.J., Richels, R.G. & Rutherford, T.F. (2009) Feasible climate targets: the roles of economic growth, coalition development and expectations. *Energy Economics*, **31**, Supp. 2, December, pp. S82–S93.
- Bowen, A., Forster, P.M., Gouldson, A., Hubacek, K., Martin, R., O'Neill, D.W., Rap, A. & Rydge, J. (2009) The implications of the economic slowdown for greenhouse gas emissions and targets. Policy paper, Centre for Climate Change Economics and Policy, November.
- Chomitz, K. (2007) *At Loggerheads: Agricultural Expansion, Poverty Reduction and Environment in the Tropical Forests*. Washington, DC: World Bank.
- Collier, P. (2008) *The Bottom Billion*. Oxford: Oxford University Press.
- Dell, M., Jones, B.F. & Olken, B.A. (2008) Climate shocks and economic growth: evidence from the last half century. NBER working paper 14132.
- DFID (2009) *Growth. Building Jobs and Prosperity in Developing Countries*. London: Department for International Development.
- Easterly, W. (2001) *The Elusive Quest for Growth: Economists' Adventures and Misadventures in the Tropics*. Cambridge, MA: MIT Press.
- Edenhofer, O., Carraro, C., Hourcade, J.-C., Neuhoff, K., Luderer, G., Flachsland, C., Jakob, M., Popp, A., Steckel, J., Strohschein, J., Bauer, N., Brunner, S., Leimbach, M., Lotze-Campen, H., Bosetti, V., de Cian, E., Tavoni, M., Sassi, O., Waisman, H., Crassous-Doerfler, R., Monjon, S., Dröge, S., van Essen, H., del Río, P. & Türk, A. (2009) *The Economics of Decarbonization. Report of the RECIPE Project*. Potsdam: Potsdam-Institute for Climate Impact Research.
- Fankhauser, S., Schelleier, F. & Stern, N. (2008) Climate change, innovation and jobs. *Climate Policy*, **8**, pp. 421–429.
- Grieg Gran, M. (2008) *The Cost of Avoiding Deforestation. An Update of the Report Prepared for the Stern Review*. London: International Institute for Environment and Development (IIED).
- Hulme, M., Neufeldt, H., Colyer, H. & Ritchie, A. (eds) (2009) *Adaptation and Mitigation Strategies: Supporting European Climate Policy. The Final Report from the*

ADAM Project. Revised June 2009. Norwich, UK: Tyndall Centre for Climate Change Research, University of East Anglia.

IFC (2007) *Selling Solar: Lessons from More than a Decade of IFC's Experience*. Washington, DC: International Finance Corporation.

Jones, B.F. & Olken, B.A. (2010) Climate shocks and exports. NBER working paper 15711, January.

Schelling, T.C. (1997) The cost of combating global warming. *Foreign Affairs*, November/December.

Schelling, T.C. (2007) Climate change: the uncertainties, the certainties, and what they imply about action. *Economists' Voice*, Berkeley Electronic Press, July, pp. 1–5.

Shalizi, Z. & Lecocq, F. (2009) To mitigate or to adapt: is that the question? Observations on an appropriate response to the climate change challenge to development strategies. *World Bank Research Observer* **25**, 2.

Stern, N. (2007) *The Economics of Climate Change*. Cambridge: Cambridge University Press.

World Bank (2010) *World Development Report 2010*. Development and Climate Change. Oxford: Oxford University Press.

World Resources Institute (2010) *Climate Analysis Indicators Tool*. Washington, DC. Available online at <http://cait.wri.org> (accessed on 1 May 2010).