Chapter 6

Reflections on the Prospects for Pro-Poor Low-Carbon Growth

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1. Introduction

Eradicating extreme poverty from the face of the earth once and for all is set to be a central goal of the emerging post-2015 development agenda. Without a rapid transition of the world economy to a low-carbon growth path over the next few decades, this ambitious goal will remain elusive.

Under current greenhouse gas (GHG) emission reduction pledges, the world is not on track to limit the average global temperature rise to +2°C above pre-industrial levels. Failure to meet this agreed target threatens to impede future progress and roll back past achievements in poverty alleviation. Prospective impact assessments indicate that for poor populations in tropical and sub-tropical hotspot regions in particular, the combination of high direct exposure, dominance of climate-sensitive sectors in economic activity and low autonomous adaptive capacity entail a high vulnerability to the predominantly harmful effects of climate change on agricultural productivity, food security, water resources, health, physical infrastructure and ecosystems.

Irrespective of the responsibility of the "Global North" for the bulk of atmospheric GHG concentration levels accumulated in the past, most of the growth in energy demand and global GHG emissions over coming decades will arise from today's developing countries. To avoid catastrophic climate change, a transition to a low-carbon growth path in today's large fast-growing middle-income countries is imperative and mitigation efforts in other developing countries are also required.

Yet developing countries are unlikely to adopt a low-carbon development strategy if such a strategy is perceived to be in conflict with domestic near-term poverty reduction aspirations. Thus, a better understanding of the potential distributional implications of different conceivable pathways to low carbon development is required to ensure the social acceptability and political viability of low carbon policy reforms. The growing recognition that the aims of equitable or pro-poor growth and low-carbon growth need to be addressed together[1] has led to efforts in the literature to identify potential synergies and trade-offs between pro-poor and low-carbon growth. This chapter provides a selective review of this literature along with some critical reflections.

To underpin the stated premises of this chapter concerning the need for climate change mitigation action in developing countries, the following section provides some quantitative background information about global GHG emission projections and targets, and about the geographical and sectoral composition of current emissions. A simple back-of-the envelope calculation is used to challenge the prevailing view that the emissions of today's least developed countries are irrelevant from a climate stabilization perspective. Section 3 contrasts arguments in favor of an early adoption of low-carbon growth strategies in low-income countries put forward in the recent literature with the dominant notion that these countries should focus on achieving growth and poverty reduction along conventional lines first and start efforts at cutting carbon emissions at a later stage. Section 4 looks at the potential direct poverty implications of adopting low-carbon development strategies in energy, agriculture and forestry, and Section 5 draws conclusions.

2. Some Unpleasant Greenhouse Gas Arithmetic

GHG Emission Projections and Targets

To maintain a reasonable chance of limiting the average global surface temperature rise to +2°C above pre-industrial levels while keeping mitigation costs at manageable levels, annual global GHG emissions would have to peak before 2020 and then drop to around 44 gigatons of CO_2 equivalent ($GtCO_2e$) in 2020, 35 $GtCO_2e$ in 2030 and 20 $GtCO_2e$ in 2050 (UNEP 2013; OECD 2012; Rogelj and Meinshausen 2010; Stern 2009). These figures are based on recent estimates of the least-cost emission trajectories consistent with the +2°C goal, and are necessarily sensitive to assumptions about technical progress and learning effects in low-carbon technologies. They are also contingent on the current state of knowledge about climate sensitivity to atmospheric GHG concentrations.

1. E.g. Stern (2009), Urban (2010a, 2010b).

Current global emissions are around 50 $GtCO_2e$ / year. A full implementation of present voluntary pledges for mitigation action submitted by developed and developing countries under the 2009 Copenhagen Accord is projected to lead to 2020 emissions of 52-56 $GtCO_2e$ in 2020, suggesting an emission gap of 8-12 $GtCO_2e$ in relation to the least-cost trajectory (UNEP 2013). In this case far higher rates of mitigation effort than implied by this least-cost scenario would be required beyond 2020, which – if technically feasible at all – will raise total mitigation costs substantially. As a case in point, about 80 percent of the power stations likely to be in use in 2020 are either already built or under construction (IEA 2010). A large fraction of these plants is fossil fuel powered and will continue to pour out carbon for decades. Prematurely closing or retrofitting such plants is a very costly option. Thus, a large fraction of the global energy-related emissions still permissible under a +2°C scenario is already locked in by the existing infrastructure (IEA 2013b). Every year of delaying decisive mitigation action exacerbates this lock-in problem. Moreover, delayed action entails a higher reliance on the large-scale deployment of potentially risky negative emission technologies in the second half of the 21st century. In short, the door to achieving the required emission cuts at a manageable cost is rapidly closing. As a result, mitigation action needs to be stepped up without further delay in the run-up to 2020, the earliest date at which a comprehensive post-Kyoto climate agreement covering the major emitters might optimistically take effect, or we run the risk that the +2ºC goal is missed by a wide margin.

A recent study by the Potsdam Institute for Climate Impact Research for the World Bank suggests that under the current mitigation commitments and pledges, there is roughly a 20 percent likelihood of exceeding 4°C by 2100, and if these pledges are not met, a warming of 4°C could occur as early as the 2060s (PIK 2012). Similarly, the latest OECD Environmental Outlook baseline scenario, which likewise assumes no mitigation efforts beyond current pledges, projects increases in the global mean temperature of +2.0ºC to +2.8ºC by 2050 and of +3.7ºC to +5.6ºC by 2100 above pre-industrial (OECD 2012). The International Energy Agency's new World Economic Outlook 2013 central scenario, which likewise takes account of mitigation measures already announced by governments, sees the world on a trajectory towards a long-term average temperature increase of +3.6 °C (IEA 2013a).

These projections are broadly in line with the synthesis of results across the whole range of state-of-the-art global circulation models reported in the new 5th Assessment Report (AR5) of the Intergovernmental Panel on Climate Change (IPCC 2013). For those two of the four representative concentration pathways (RCPs) that are consistent with low or moderate effective mitigation efforts considered in IPCC (2013), namely RCP6.0 and RCP8.5, the report states: "global temperatures averaged in the period 2081–2100 are …*likely* to exceed 2°C above preindustrial for RCP6.0 and RCP8.5 (*high confidence*). Warming above 4°C by 2081–2100 is *unlikely* in all RCPs (*high confidence*) except for RCP8.5 where it is *as likely as not* (*medium confidence*)".[2] The 5-95 percent range of across model projections towards the last decades of the century is +2.0 to +3.7°C under RCP6.0 and +3.2 to +5.4 °C under RCP8.5.

It is worth noting that projected temperature increases are not uniformly distributed across the globe. Projected increases for some regions are far higher than the global average. In view of these recent climate projections, scientists are starting to get serious about contemplating human development prospects in a +4°C world.[3]

The Decomposition of Present GHG Emissions by Region of Origin and Sector

Table 1 displays global GHG emissions in 2010 by country or country group of origin and their shares of world emissions ordered by emission volume for the 21 top emitters (countries that account for 80 percent of total emissions and for 70 percent of the world population). Importantly for the purposes of the present chapter, the figures include emissions from agricultural activity and land use change.

On a production basis, developed countries now account for less than 40 percent of total emissions with a declining trend, while the four top developing country emitters - China, India, Brazil and Indonesia – alone account for 33 percent of global emissions with a rising trend. It is evident from the Table that a significant contribution to GHG mitigation efforts from these and other developing countries is required to bring

2. In IPCC terminology, the terms very likely, likely, and as likely as not mean likelihoods of 66-100, 33-66, and 0-33 percent respectively. Note that among all no-mitigation baseline scenarios reviewed in the AR5 "none is consistent in the long run with the pathways in the two most stringent RCP scenarios …, with the majority falling between the 6.0 and 8.5 pathways" (Clarke and Jiang 2013, 17).

3. See e.g. New et al. (2011), Thornton et al. (2011), PIK (2013).

emissions on a sustainable path. Even if the developed Annex I countries do hypothetically cut emissions to zero over night, the total would remain well above – and diverge further from – the least-cost sustainable path outlined above without further mitigation efforts beyond current developing country pledges. It is noteworthy in this context that the developing country origin share of *cumulative* GHG emissions (again including those from agriculture and land use change) since 1850[4] is now roughly equal to the developed country share, and it has been estimated by den Elzen et al. (2013) that this share will reach 56% by 2020.

To avoid any misinterpretations here: this is not a normative discussion about climate justice. The sole purpose is to show where geographically a large portion of future mitigation action must necessarily take place to achieve the climate stabilization goal – it is not an argument about who is morally responsible to pay for such mitigation action.

Are LDC Emissions Really Irrelevant from a Mitigation Perspective?

The least developed countries contribute a small but non-negligible 5% (Table 1). However, this share is bound to rise significantly over the first half of the 21st century as a result of population and income growth, and more so if a carbon-intensive growth path is taken. This can be demonstrated with a simple back-of the-envelope calculation: Let E and N denote total annual LDC emissions and population respectively. Proportional differentiation of the accounting identity $E = (E/N)\cdot N$ yields $g_E = g_{E/N} + g_N$. Defining the elasticity of per-capita emissions with respect to per-capita income Y/N as $\varepsilon = g_{E/N} / g_{Y/N}$, we obtain $g_E = \varepsilon \cdot g_{Y/N} + g_N$. The latest UN medium-variant population projections see the total population of today's LDCs grow from 832 (Table 1) to 1,726 million over the period 2010-50, which equates to an average annual growth rate of $g_N = 0.0184$, i.e. 1.84 percent. With an assumed moderate annualized per-capita LCD income growth of $g_{Y/N} = 0.03$ over the same period[5] and setting ε to a moderate 0.3[6], the average annual emission growth rate

4. Cumulative emissions are significant because they determine current atmospheric GHG concentration levels and hence climate change,

5. Many LDCs reported far more impressive growth rates in recent years.

6. Under this assumption, a one-percent increase in per-capita income is associated with a sub-proportional 0.3 percent increase in per-capita emissions. See e.g. Jobert, Karanfil and Tykhonenko (2013) for recent empirical evidence on the relation between income and emissions at low-income levels and further reference to the empirical literature. Estimates of ε vary widely across studies and countries.

would be $g_E = 0.0274$. Thus, total LDC emissions would nearly triple from 2.3 (Table 1) in 2010 to $2.3 \cdot (1+g_E)^{40} \approx 6.8$ $GtCO_2e$ / year in 2050, even though emissions per head rise only moderately from 2.8 (Table 1) to 3.3 tCO_2e under these assumptions. With only a slight increase in ε to 0.4 and in $g_{Y/N}$ to 0.04, the same calculation would lead to LDC emissions of 9.0 $GtCO_2e$ / year with per-capita emissions of 5.2 in 2050 - that is nearly half of the total global emissions permissible in 2050 under the least-cost mitigation path outlined above.

These basic calculations indicate that the widely held view that LDC emissions are largely irrelevant from a global mitigation perspective does not hold up well to closer scrutiny. Moreover, the widespread perception that these countries must focus exclusively on the promotion of growth unconstrained by low-carbon considerations and on adaptation measures to bolster their future resilience to climate change impacts should also be reconsidered.

An even simpler way to demonstrate the basic problem with this is view is to just calculate the global average GHG emission levels per head in 2050 consistent with the goal to reach 20 $GtCO_2e$ by then: with a projected world population of 9.3 billion (UNDESA 2011a; medium variant) that is 2.15 tCO_2e / head. As shown in the last column of Table 1, the LDCs as a group are already slightly above that level, and any significant increase in that level would necessitate even deeper cuts by other countries and would further increase the likelihood that the +2°C goal is missed by a wide margin.

Table 1. Greenhouse Gas Emissions 2010 by Region

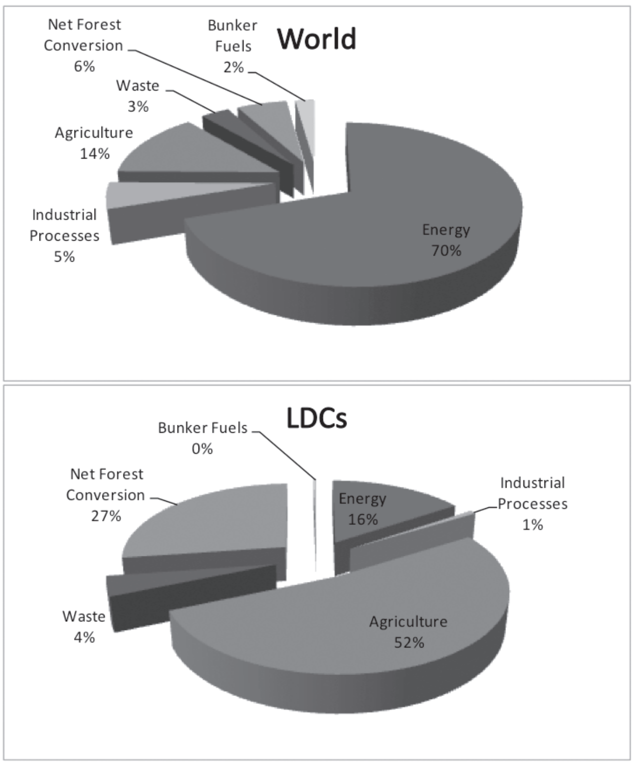
	Emissions	Share	Cumulated Share	Population	Share	Emissions per capita
	Gt CO2e	*%*	*%*	*Mill*	*%*	*t CO_2e/head*
China	10.1	21.4	21.4	1,341	19.4	7.5
United States	6.8	14.4	35.7	310	4.5	21.9
European Union (27)	4.8	10.2	45.9	500	7.3	9.6
Russian Federation	2.3	4.9	50.9	143	2.1	16.2
India	2.3	4.9	55.7	1,224	17.7	1.9
Brazil	2.1	4.5	60.3	195	2.8	11.0
Japan	1.3	2.8	63.0	127	1.8	10.2
Indonesia	1.2	2.5	65.5	240	3.5	4.9
Australia	0.7	1.6	67.1	22	0.3	33.5
Iran	0.7	1.5	68.6	74	1.1	9.8
Canada	0.7	1.5	70.1	34	0.5	21.4
Mexico	0.7	1.5	71.6	113	1.6	6.3
South Korea	0.7	1.4	73.1	48	0.7	14.2
South Africa	0.6	1.2	74.3	50	0.7	11.2
Saudi Arabia	0.5	1.1	75.4	27	0.4	20.1
Argentina	0.5	1.0	76.4	40	0.6	11.3
Venezuela	0.4	0.8	77.2	29	0.4	13.3
Ukraine	0.4	0.8	78.0	45	0.7	8.5
Turkey	0.4	0.8	78.8	73	1.1	4.8
Malaysia	0.3	0.7	79.5	28	0.4	12.0
Pakistan	0.3	0.7	80.2	174	2.5	1.9
Sum (Average)	37.8	80.2		4,837	70.1	(7.8)
World	47.2	100.0	100.0	6,869	100.0	6.8
Annex I Countries	17.7	37.5		1,207	17.5	14.7
Non-Annex I Countries	29.5	62.5		5,689	82.5	5.2
Least Developed	2.3	5.0		832	12.1	2.8

Source: World Resources Institute CAIT 2.0 Data Base (accessed January 2014).
Note: "Annex I" countries are the established industrialized countries (i.e. OECD members as of 1992 plus Eastern European economies in transition) with emission reduction obligations under the Kyoto protocol, while "Non-Annex I" countries are developing countries without such obligations.

The Decomposition of Present GHG Emissions by Sector

The two panels of Figure 1 show the 2010 GHG emission shares by broad type of activity for the world as a whole and for LDCs respectively. While on a global scale, anthropogenic emissions are dominated by energy-related activities, in LDCs as a group, agriculture and land use change account for nearly 80 percent of the total. It should be noted that emissions from agriculture and land-use change are more difficult to measure than energy emissions, and some estimates in the literature record far higher global shares for the former than the World Resources Institute estimates reported here. The future evolution of these shares depends obviously on the qualitative features of the growth paths taken over the coming decades.

Figure 1. Greenhouse Gas Emissions by Source 2010
(Percentage shares in total GHG emissions)



Source: Author's calculations based on World Resources Institute CAIT 2.0 Data Base (accessed January 2014).

3. The Case for Low-Carbon Growth in Low-Income Countries

A key message of the previous section is the necessity to reconsider the dominant notion that poorer countries in general and LDCs in particular should focus on achieving growth and poverty reduction along conventional lines first and start worrying about cuts in carbon emissions at a later stage. This notion rests primarily on the argument that the adoption of low-carbon technologies raises costs and consumer prices in relation to conventional alternatives, entailing adverse impacts on growth and hence poverty alleviation. A slow down in growth-driven poverty reduction implies in turn a higher vulnerability to climate change impacts. Moreover, early mitigation action would divert attention, funding and scarce planning capacity away from more pressingly needed adaptation investments. Further arguments in support of the "grow first – decarbonise later" view are that low-carbon technologies can be expected to be available at lower costs in the future, and that on intertemporal equity grounds, the current poor should not be obliged to incur consumption sacrifices in favor of future, supposedly wealthier, generations.

However, this view requires qualification for a number of reasons. Most importantly, it violates basic economic efficiency principles – and in doing so ignores a potentially large source of gains from international exchange for low-income countries: to achieve a given global GHG emission target at minimum cost, the marginal GHG abatement costs would have to be equalized across all regions of the world. In plain language, it makes no sense to install low-carbon technologies in rich region A at a cost of $50 per ton of CO_2e avoided as long as the same amount of emission reduction can be achieved at a cost of $10 per ton in poor region B. Such mitigation cost differences imply the presence of potentially large mutual gains from carbon credit transactions between developed and developing countries. Quantitative estimates show a huge potential for these mutual gains. A recent model-based global study by Akimoto et al. (2010) indicates a far larger near-term low-cost emission reduction potential up to 2020 in the developing non-Annex I countries than in the in the developed Annex-I countries (Table 2). This finding is consistent with the meta analysis of results from similar model-based studies with a time horizon towards 2030 by van Vuuren et al. (2009), which finds unanimous agreement among existing estimates that the largest mitigation potentials are in non-OECD countries.

Table 2. Estimated GHG Emission Reduction Potentials in 2020

(Deviations from 2020 baseline in $GtCO_2e$/year at abatement costs <0 and <20 US$/$tCO_2e$)

	< 0 $/$tCO_2e$	< 20 $/$tCO_2e$
USA	1.7	2.4
EU27	1.2	1.8
All Annex-I	3.3	4.3
China	6.9	10.6
India	3.3	4.3
Brazil+Indonesia+South Africa	1.2	1.7
Other Non-Annex I	3.9	6.2
World	20.2	30.1

Source: Akimoto et al (2010: Table 4) and author's calculation.
Notes:"Annex I" countries are developed countries with emission reduction obligations under the Kyoto protocol, while "Non-Annex I" countries are developing countries without such obligations. The baseline assumes constant emission intensities.

In the absence of a full global cap-and-trade system, the Kyoto flexible mechanisms including the Clean Development Mechanism (CDM) as well as the upcoming REDD+ (Reducing Emissions from Deforestation and Degradation) scheme are in conception key devices for the realization of the mutual gains arising from abatement cost differences across regions and must be scaled up significantly under the emerging post-Kyoto climate finance architecture. As far as the envisaged new market-based mechanisms that will supersede or complement the CDM provide full funding and technical assistance for early mitigation action in poorer countries from developed country sources, domestic growth prospects need not be adversely affected, and the recipient regions may benefit from additional ancillary benefits as elaborated below. A sufficiently high carbon price is a necessary precondition for the effectiveness of any such market-based mechanism in mobilizing low-carbon investment flows from richer to poorer countries at scale. This in turn will require a global climate agreement with stringent binding targets for the major emitters. Proposals favoring a system of voluntary pledges are in this respect "about as useful as a chocolate tea pot", as former UK Climate Secretary Chris Huhne has put it.[7]

Taken at face value, the presence of mitigation options with a negative abatement cost in Table 2 would mean possibilities for immediate mitigation measures with positive net gains even in the absence of payments flows from rich countries. The presence of such negative-cost mitigation options in poor countries undermines in itself the basic

7. Cited in Harvey (2011).

premises of the "develop first – decarbonize later" position.[8]

A further argument in favor of the early adoption of a low-carbon growth path – that applies specifically to the least developed regions with a rudimentary present energy infrastructure, emphasizes the benefits of avoiding a high-carbon technology lock-in right from the start. Given the long-lived nature of energy plant and infrastructure investments and the associated high cost of premature scrapping, choosing low-carbon modes of development now will reduce the economic burden of GHG gas mitigation in the future (OECD 2013; Byrne et al. 2011; Bowen and Fankhauser 2011).[9] Moreover, as technical progress in the energy sector will shift to low-carbon technologies, once a global climate deal is eventually reached, LDCs that have embarked on a traditional high-carbon development trajectory will be stuck with a stagnant type of technology and will not be able to benefit from this technical progress (Bowen and Fankhauser 2011).

Another economic reason for embracing a low-carbon growth strategy is the avoidance of prospective adverse impacts on future export growth performance. Such adverse trade impacts would arise if countries with strong mitigation efforts impose border tax adjustments on carbon-intensive imports from countries on a high-carbon growth path, or if better-off consumers – including households belonging to the growing middle class in developing countries – switch their preferences to green low-carbon alternatives (e.g. Rowlands 2011; Bowen and Fankhauser 2011).

The literature identifies a further range of co-benefits for countries adopting a low-carbon development strategy. Such ancillary benefits include the effects of reduced air pollution on mortality and morbidity, greater energy security and the relaxation of foreign exchange due to reduced dependence on fossil fuel imports, and potential positive net employment effects that arise if "green" low-carbon job creation in the

8. Economists tend to be sceptical about models and arguments that suggest the existence of unpicked dollar bills on the sidewalk. Capital market imperfections and incomplete information are among the most obvious explanatory factors for the presence of unexploited negative-net-cost investment opportunities, given that upfront investments are required to reap the stream of future net negative operating costs (that arise, for example, due to large fuel cost savings as a result of investments in energy efficiency or a switch to renewables).

9. Essentially the same lock-in argument applies to non-energy infrastructure investments and planning decisions with a largely irreversible character such as in the areas of transport and urban development– see Pye et al. (2010).

course of the low-carbon transformation exceeds "brown" job destruction.

Such co-benefits figure prominently in the existing literature on pro-poor low-carbon development. Indeed much of this literature appears to be entirely fixated on the identification and propagation of win-win measures that promise the simultaneous achievement of mitigation and poverty reduction objectives by co-incidence.[10] From a political economy perspective, this fixation is understandable, given that prospects for double or triple wins open up opportunities for the formation of alliances among multiple policy actors with differing priorities in support of such measures. However, an exclusive focus on such synergetic measures unduly narrows the space of potential policy options by ignoring a basic insight from the theory of economic policy in the tradition of Jan Tinbergen (1952), joint winner of the first Nobel Prize in Economics back in 1969: the best possible achievement of multiple policy objectives generally requires the combination of multiple policy instruments.

In the present context, this means that a narrowly conceived pro-poor low-carbon growth strategy that rules out policies with a high mitigation potential but without co-incidental pro-poor benefits - or with adverse primary distributional side effects - is likely to generate inferior outcomes compared to a strategy that combines such mitigation policies with the application of feasible redistributive measures.

4. How Pro-Poor is Low-Carbon Growth? A Closer Look

Poverty Implications of Low-Carbon Growth in the Energy Sector

Any consideration of the poverty implications of low-carbon growth must start from the fact that presently some 1.3 billion people lack access to electricity (IEA 2013a), another billion people only have access to unreliable electricity (Casillas and Kammen 2010), and about 2.6 billion people rely on traditional biomass, such as wood, dung and charcoal for cooking and heating purposes (IEA 2013a).

Given that achieving universal access to modern energy services is a co-

10. Proponents of "climate-smart" development strategies go one step further by promoting the pursuit of "triple win" policies that generate adaptation co-benefits on top of mitigation and poverty reduction benefits.

requisite for the eradication of extreme poverty, these figures might at first sight suggest a fundamental conflict between the global climate stabilization and poverty elimination goals. However, a recent scenario analysis by the International Energy Agency (IEA 2010) suggests that it is technically and economically feasible to reach universal access to a basic level of modern energy services by 2030 with an increase in CO_2 emissions of merely 0.8 percent relative to a 2030 baseline scenario in which 1.2 billion remain without electricity access.[11]

In the IEA universal access scenario all urban and peri-urban households are connected to the national grid by 2030, while in rural areas 70 percent of the new access is provided via decentralized mini-grid and off-grid systems including solar photo-voltaic, mini-hydro, wind, biomass and geothermal systems. In the recent low-carbon development literature, the deployment of such decentralized renewable energy systems is widely seen as a promising and economically viable approach to reduce energy poverty in remote rural areas. Apart from the direct poverty reduction impacts associated with electrification in general (such as the extensions of hours available for income generation and education activities), the provision of these systems is seen to generate further pro-poor growth benefits by creating local jobs in related hardware manufacturing, distribution, installation and maintenance.[12]

A recent study by Deichmann et al. (2011) for Ghana, Ethiopia and Kenya uses spatial modeling in combination with engineering cost estimates to determine where stand-alone renewable energy generation is a cost-effective alternative to centralized grid supply. The results indicate that decentralized renewables are competitive mostly in remote

11. Global electricity generation rises by 2.9 percent and oil demand by one percent relative to the 2030 baseline levels. In the baseline scenario, global CO_2 emissions in 2030 are 21 percent higher than in 2008. Chakravarty and Tavoni (2013) consider a more ambitious global energy poverty eradication scenario that includes the provision of electricity and fuels to increase productivity in agriculture, commercial activities and transport to 3.4 billion energy-poor people, in addition to universal access to basic energy services to satisfy basic human needs for 1.8 billion people by 2030. In this scenario, global final energy consumption rises by 7 percent relative to the baseline.

12. See e.g. UNEP/UNCTAD/UN-OHRLLS (2011), World Bank (2012), UNDESA (2011b), Casillas and Kammen (2010), Grantham Institute (2009). Of course, the extent to which such green job creation is directly pro-poor depends in particular on the skill intensity of these jobs and the empirical evidence for developing countries is weak in this respect (Dercon 2014). For a detailed systematic review of the empirical evidence on the benefits of increased renewable energy capacity for poor people see Pueyo et al. (2013).

rural areas, while grid-connected supply is the cheaper option in more densely populated areas where the majority of households in these countries reside. These findings confirm that decentralized renewable energy can play an important role in expanding rural energy access in Sub-Saharan Africa (SSA), but the results also underscore the need to pay attention to the evolution of the fuel mix for centralized power generation.

As Collier and Venables (2012) point out in this respect, Africa is well endowed with potential for hydro and solar power, but lacks capital, skills and governance capacity. Since distributed solar power is very capital and skill-intensive, the authors conclude that the international community must provide support by increasing Africa's supply of these scarce factors. In line with the argument in section 2, the CDM is seen as one of the appropriate instruments to provide this support.

Timilsina et al. (2010) investigate the potential of reducing energy-related GHG emissions via the CDM across 44 countries in SSA through the CDM. The study looks at a wider range of low-carbon technology options and finds that over 3,200 CDM projects that meet the eligibility criteria could be developed in the region. The cumulated GHG mitigation potential over the 10-21 year CDM project cycle is estimated to amount to 9.8 $GtCO_2$. However, the realization of this potential is contingent on effective assistance in overcoming a range of implementation barriers that partly explain the very low number of CDM projects in the region up to the present. The barriers to implementation identified in this study include inter alia lack of infrastructure, institutional capacity and local skilled labor as well as potential foreign investors' perceptions of SSA as a high-risk region.

In addition to electrification, the IEA (2010) Universal Access Scenario also envisages the provision of access to clean cooking facilities (in the form of LPG stoves or advanced biogas/biomass stoves) for the 2.8 billion people still relying on traditional biomass in the 2030 baseline scenario. Recent estimates suggest that the associated emission reductions could exceed 1 Gt CO_2e per year (Lee et al. 2013) – that is a significant figure in relation to the global emission targets outlined in Section 2. The pro-poor co-benefits of a suitably subsidized roll-out of clean efficient stoves is evident. According to World Health Organization estimates, currently in-door air pollution causes 2 million premature deaths per year (WHO 2011), or more annual deaths than are caused by malaria, tuberculosis or HIV (UNDESA 2011b). In addition to the direct health impacts and health-related productivity gains, the pro-poor ancillary benefits include fuel collection and cooking time savings. A global cost-benefit analysis of a hypothetical intervention that provides access to clean stoves for 50 percent of the population lacking such access in 2005 by Hutton, Rehfuess and Tediosi (2007) reports a benefit-cost ratio on the order of sixty.

Distributional Implications of Fossil Fuel Subsidy / Tax Reform

To achieve the transition to a low-carbon growth trajectory in market-based economies, relative prices between fossil fuels and low-carbon energy sources play a decisive role. It is critical that the fossil fuel prices faced by market participants reflect the long-run marginal social costs associated with GHG emissions in order to incentivize the required structural transformation of the energy system as well as to induce energy efficiency investments and shifts to less carbon-intense demand patterns. Fossil fuel subsidies distort relative prices and pervert incentives exactly in the opposite direction. Their swift phasing-out must be part of any effective low-carbon growth strategy.

According to the latest IEA (2013a) estimates, fossil-fuel consumption subsidies worldwide amounted to US$544 billion in 2012, a large portion of which is attributable to developing and emerging countries. Separate estimates for OECD countries based on a different methodology suggest indirect public support measures for fossil fuel production and use in developed countries on the order of US$45-75 billion per annum in recent years (OECD 2011). At a global scale, fossil fuel subsidies are six times higher than the financial support given to renewables (IEA 2013b). Phasing out these subsidies could provide around half the emissions reductions needed over the next decade to reach a trajectory that would limit global warming to +2°C.

Fossil fuel subsidies in developing countries are commonly justified as a means to make modern energy services affordable to the poor, and their removal is widely seen to hurt poor households disproportionally. Fact is, however, that fuel subsidization is a grossly inept instrument to target the poor. Using data for a sample of 20 developing countries, Arze del Granado, Coady and Gillingham (2012) show that on average across sample countries, households in the top income quintile receive 42.8 percent of the benefits from fuel subsidies while the bottom quintile receives only 7.2 percent. This implies that the average burden to government budgets of transferring one dollar to the poor quintile is a mindboggling US$13.89, as nearly 93 percent of the subsidy leaks to the higher quantiles.[13]

This is not to deny that the direct impacts of fuel subsidy cuts on fuel prices and on the prices of other goods via input-output linkages viewed in isolation will hit the poor, along with better-off households and production sectors intense in the use of fossil fuels or fossil-fuel-based power. But the ultimate distributional impact of such cuts, as well as their political feasibility, depends crucially on how governments use the additional fiscal space created by the reduced burden on government budgets.

As illustrated by a recent background study by Willenbockel and Hoa (2011) for UNDP (2012), adverse distributional and growth side effects of fossil fuel subsidy cuts are by no means inevitable. A dynamic scenario analysis based on a general equilibrium suggests in particular that adverse impacts on poor households can be neutralized (or turned into pro-poor impacts) by using part of the government savings arising from the subsidy cut for compensating cash transfers. Using the additional fiscal space to foster additional productive and more energy-efficient investments may actually raise income and consumption for all households in the medium run. The same argument applies to the hypothetical introduction of a carbon tax, also considered in this study, as the direction of the first order effects is essentially equivalent to that of a fossil fuel subsidy cut. The general tenor of these findings is broadly in line with the results of similar *ex-ante* general equilibrium simulation studies surveyed by Ellis (2010) and Boccanfuso et al. (2008). In short: fossil fuel subsidies are definitely not pro-poor – their elimination can be.

Poverty Implications of a Low-Carbon Transition in the Agriculture and Forestry Sector

Direct GHG emissions from agriculture (Figure 1 above), exclusive of

13. The average figures mask even more extreme cases of bad policy targeting (taking the pro-poor motive for such subsidies at face value) that become apparent by looking at the disaggregated results for country groups and fuel types in Arze del Granado, Coady and Gillingham (2012: Table 12). E.g. in Africa, only 2.2 percent of gasoline subsidies reach the bottom quintile, implying a budgetary burden of over US$45 to transfer a single dollar to the poorest quintile through this instrument.

forest conversion into agricultural land, consist primarily of N_2O (nitrous oxide) associated with fertilizer use, MH_4 (methane) associated with enteric fermentation emissions from livestock and emissions from rice paddies and manure, and to a lesser extent, of net CO_2 fluxes to the atmosphere associated with degradation of organic soils in tropical regions (Smith et al. 2008, 2013; Olander et al. 2013).

Potential mitigation measures include various changes in land and livestock management practices as detailed in Smith et al. (2008; 2013) and Lal (2011). As far as adverse direct and indirect land use change effects that could lead to a net *increase* in emissions can be avoided, biofuel production may be seen as a further option for mitigation action in the agricultural sector.

Smith et al. (2008) estimate the *technically* feasible global technical GHG mitigation potential from agriculture excluding fossil fuel offsets from biofuels by 2030 to be in the order of 5.5 to 6 Gt CO_2e per year with *economic* potentials of 1.5 to 1.6, 2.5 to 2.7 and 4.0 to 4.3 at carbon prices of up to US$20, 50 and 100 per ton of CO_2e respectively. The additional economic mitigation potential of replacing fossil fuels by biomass energy from agriculture is estimated to be 0.64, 2.24 and 16.0 Gt CO_2e per year for the same three marginal abatement cost ranges.

However, any consideration of the potential contributions of agriculture in developing countries to GHG mitigation must take into account that the combination of population growth and rising per-capita incomes that will be accompanied by a shift towards more livestock-intense diets in parts of the world will translate into a substantial increase in the demand for agricultural output between now and the middle of the century. These demand-side drivers are bound to intensify the competition for land and water, particularly in low-income regions with high population growth and a high present incidence of undernutrition.[14]

The need to adapt to the emerging impacts of climate change that are already locked into the system even under the most optimistic assumptions about future mitigation efforts adds to the pressure for low-income regions. Long-run agricultural productivity trends as well as short-run yield variability are directly affected by climate change and the associated expected increases in extreme weather events. A growing

14. Government Office for Science (2011); Godfray et al. (2010).

number of studies suggest that climate change may well reduce the productivity of farming in precisely those regions of the world where undernutrition is already most prevalent.[15]

Moreover, climate change mitigation policies aimed at the energy sector that raise fossil fuel prices would drive bioenergy demand upwards even in the absence of biofuel mandates and further intensify the competition for land. An extensification response in the form of converting forestland to farmland is obviously not a sustainable option, as net forest conversion would further add to emissions and reinforce the problem.

It is precisely this confluence of pressures on agricultural systems that led the UK Government Foresight Report on the future of food and farming (Government Office for Science 2011) to the conclusion that the increase in the global food supply must be based on sustainable intensification. Sustainable intensification means simultaneously raising yields, increasing the efficiency with which inputs are used and reducing the GHG emissions associated with food production. It is a core principle of the wider notion of a climate-smart agriculture (CSA) that seeks to "(i) sustainably intensify production systems to achieve productivity increases, thereby supporting the achievement of national food security and development goals; (ii) increase the resilience of production systems and rural livelihoods (adaptation); and (iii) reduce agriculture's GHG emissions (…) and increase carbon sequestration (mitigation)" (Branca et al. 2012).

A gradual move to a growth path based on this conception in the rural areas of SSA and South Asia with support from developed countries is in principle a pro-poor strategy, as it would raise returns to agricultural labor over time and speed up the structural transformations required to achieve the longer-term aim of eradicating extreme poverty. Pretty, Toulmin and Williams (2011) review 40 sustainable intensification projects with a coverage of 12.8 million ha of land across 20 African countries. They report an average yield increase across these projects by a factor of 2.13, benefiting 10.4 million farmers and their families.[16]

15. See Willenbockel (2014) for further reference. See also Nelson et al. (2014).

16. For further reference to empirical case study evidence on yield improvements and poverty impacts associated with the adoption of sustainable intensification practices see inter alia UNEP (2011), Cooper et al. (2013), ILO (2012: Ch.2), World Bank (2012: Ch.5), Shames et al. (2012).

The potential role of biofuel production within pro-poor low-carbon growth strategies remains a highly contested issue. The suitability of traditional food-crop-based first-generation biofuels, except for sugar cane based fuels, for the achievement of significant net GHG reductions is increasingly being called into question. However, various recent global scenario studies exploring feasible emission pathways to achieve the +2°C goal see an indispensable role for second-generation ligno-cellulosic biofuels in the future energy mix.[17] These emergent advanced second-generation biofuels are based on non-edible inputs, including crop and forest residues, grasses (switchgrass, miscanthus) or fast-growing trees (poplar, willow, eucalyptus) that can be grown on marginal and degraded land not suitable for food crop production and are expected to have a far higher net GHG reduction potential than conventional first-generation bioenergy feedstocks (Lotze-Campen et al. 2014; OECD 2013).

For parts of SSA in particular, the hope is that a carefully regulated allocation of marginal land to next-generation bioenergy production could avoid the risks of harmful effects on poor people widely associated with a large-scale conversion of land for commercial first-generation biofuel production.[18] This includes risks such as the uncompensated loss of access to land for smallholders with precarious customary land tenure rights and adverse food security impacts. Lynd and Woods (2011) envisage a large future potential of pro-poor benefits for Africa offered by an integration of second-generation bioenergy conversion technologies into agricultural value chains and outline the requirements for a realization of these benefits.

Through their implications for land use and access to land, mitigation measures in agriculture are closely interconnected with measures to achieve reduced emissions from deforestation and forest degradation (REDD), and the potential poverty impacts of the latter are likewise subject to controversial debate. A major bone of contention in the voluminous pertinent literature is how alternative design options for the REDD+ carbon finance scheme under a global post-Kyoto climate agreement affect the livelihoods of poor forest users. There are concerns as to how safeguards can be established to ensure that the interests of national elites and international investors do not override the rights of

17. See Lotze-Campen et al. (2014) for reference to these scenario studies.
18. See e.g. Cotula, Dyer and Vermeulen (2008) and Mitchell (2011).

local forest communities and that an equitable share of the REDD+ benefits reaches the poorest members of these communities.[19]

Meanwhile, the UNFCCC 19th Conference of Parties in December 2013 has agreed upon the Warsaw Framework for REDD+, which specifies the key design features of the future scheme that would take effect if a global deal is reached in 2015. The Framework includes safeguard clauses that aim to ensure that REDD+ is implemented in equitable ways and in accordance with a country's sovereignty. Notably, it contains a requirement for recipient countries of carbon finance to publish periodic information on how these safeguards are being addressed and respected.

5. Concluding Remarks

The point of departure and motivation for this chapter is the joint proposition that there will be no lasting global poverty eradication without low-carbon growth and no global low-carbon transition without poverty reduction. Or as Nicholas Stern (2009) has put it emphatically, "(t)he two defining challenges of our century are overcoming world poverty and managing climate change. If we fail on one, we fail on the other." Thus, the aims of equitable or pro-poor growth and low-carbon growth are intrinsically linked and need to be addressed together.

A closer look at the basic merciless algebra of global GHG emissions and low-cost mitigation pathways reveals an important message: the prevailing view that the emission paths of today's least developed countries are largely irrelevant from a global mitigation perspective is demonstrably mistaken. In fact, average LDC emissions per capita are already higher now than the maximum average global per-capita emissions permissible in 2050 if the +2°C target is to be reached at manageable mitigation costs. Thus, the widely held view that over the next few decades these countries should focus exclusively on the promotion of growth unconstrained by low-carbon considerations and on adaptation measures to bolster their future resilience to climate change impacts, needs to be reconsidered.

19. E.g. Brown, Seymour and Peskett (2008) and Funder (2009) fur further elaboration. For alternative critical perspectives see Leach and Scoones (2013) and Fairhead, Leach and Scoones (2012).

Fortunately, there are a number of good economic reasons why it could be in LDCs' own self-interest to adopt a low-carbon growth strategy at an early stage. In particular, (i) the large potential for low-cost mitigation measures in the developing world including LDCs provides opportunities for substantial mutual gains from carbon credit transactions between developed and developing countries; (ii) choosing low-carbon modes of development now will reduce the economic burden of GHG gas mitigation in the future by avoiding a high-carbon technology lock-in; (iii) the avoidance of potential adverse impacts on future export growth performance in the case of border tax adjustments and shifts in consumer preferences to low-carbon varieties in other countries; (iv) the realization of gains from lower outdoor / indoor pollution; and (v) improvements in energy security and the relaxation of foreign exchange constraints due to less dependence on fossil fuel imports.

But how pro-poor is the transition to a low-carbon growth path? The existing literature on pro-poor low-carbon development identifies a range of clear synergies between mitigation and poverty reduction objectives, but as the selective discussion of the prospects for the transition to a pro-poor low-carbon path in the agriculture, forestry and energy sectors of low-income countries in this chapter indicates there are also trade-offs. A narrow conception of pro-poor low carbon growth strategies that focuses exclusively on the implementation of coincidental win-win measures aims too short, if redistributive measures are feasible that could reverse the ultimate equity outcomes of policies with high mitigation impact but adverse primary impacts on poverty. The removal of fossil fuel subsidies and the introduction of a carbon tax discussed in this chapter illustrate the point. The direct price impacts of these mitigation policies are bound to hit the poor along with the better-off, but the joint use of distributive measures could in principle generate a positive net impact on the poor. More generally, multiple policy objectives call for the use of multiple policy levers.

The key message of this chapter is that a success of the adoption of pro-poor low-carbon strategies by low-income countries with significant mitigation potential along the lines outlined above requires development cooperation efforts between high- and low-income countries on an unprecedented scale. This includes the completion and implementation of a comprehensive global climate agreement with binding targets and effective and sufficiently funded mechanisms for the transfer of carbon finance flows as an essential prerequisite.

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