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Zero poverty, zero emissions

Eradicating extreme poverty in the climate crisis

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Key messages

- **Eradicating extreme poverty is achievable by 2030, through growth and reductions in inequality.** Sustained economic growth in developing countries is crucial for poverty eradication, but it is likely to be more moderate and less effective in reducing extreme poverty in the coming decades than the prior ones. Addressing growth and inequality together is far more effective. This requires building poor people's human capital (through nutrition, health and education) and assets, their access to infrastructure, services, and jobs, and their political representation.
- **Avoiding catastrophic climate change requires global emissions to peak by around 2030 and fall to near zero by 2100.** Nearly all the IPCC's mitigation scenarios indicate that the global economy must reach zero net greenhouse gas emissions before the century's end to hold the global mean temperature rise to less than 2°C, the limit beyond which the world will face 'dangerous anthropogenic interference' with the climate (UNFCCC 2009). Most of these scenarios require global emissions to peak by around 2030, the deadline of our global poverty eradication target.
- **Unchecked, climate change could draw up to 720 million people back into extreme poverty just as we approach the zero poverty goal.** This estimate factors in only the most quantifiable impacts on the world's extreme and moderately poor during the period 2030-2050 if current emissions trends continue, heading toward 3.5°C mean temperature change by the century's end.
- **Poverty eradication cannot be maintained without deep cuts from the big GHG emitters.** It is policy incoherent for big GHG emitting countries, especially industrialised ones, to support poverty eradication as a development priority, whether through domestic policy or international assistance, while failing to shift their own economy toward a zero net emissions pathway. The costs of adaptation simply become implausible beyond 2°C.
- **Low emissions development is both necessary for, and compatible with, poverty eradication.** The achievement of global zero net emissions requires action by countries across all levels of development, moving to development strategies that anticipate the need for declining emissions from 2030 toward the zero emissions goal. Evidence to date shows this is compatible with poverty eradication. In the regions of the world home to the extreme poor, studies show that most emissions reductions necessary by 2030 can enhance growth by anywhere between 1.4% and 3.9%.

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Abbreviations

ASEAN	Association of Southeast Asian Nations
BAU	Business as usual
CO2	Carbon dioxide equivalents
CPAN	Chronic Poverty Action Network
CRGE	Climate Resilient Green Economy
ETP	Energy Technology Perspectives
FAO	Food and Agriculture Organization
GHG	Greenhouse gas
GDP	Gross Domestic Product
HDI	Human Development Index
IEA	International Energy Agency
IPCC	Intergovernmental Panel on Climate Change
LDCs	Least-developed countries
LIC	Low-income country
LMIC	Lower-middle income country
MACC	Marginal Abatement Cost Curve
MDG	Millennium Development Goals
MIC	Middle-income country
MPI	Multidimensional Poverty Indicator
NCE	New Climate Economy
OECD	Organisation for Economic Co-operation and Development
ppm	Parts per million
PPP	Purchasing Power Parity
RCP	Representative Concentration Pathways
SA	South Asia
SEA	Southeast Asia
SSA	Sub-Saharan Africa
SE4ALL	Sustainable Energy for All
UN	United Nations
UNFCCC	United Nations Framework Convention on Climate Change
UNDP	United Nations Development Programme
WEO	World Energy Outlook
WHO	World Health Organization
°C	Degrees Celsius

Executive summary

The eradication of extreme poverty is the minimum ethical floor of the global development agenda. With projections suggesting eradication is possible by 2030, the goal of 'zero extreme poverty[1] by 2030' is a compelling objective. It has become a central target underpinning the Sustainable Development Goals, and is one of the few that shows strong progress based on current trends (Nicolai et al., 2015).

Progress over the past two decades has reduced the percentage of people living on less than $1.25 a day in the developing world—the extreme poor—from 43% in 1990 to about 17% as of 2011. This is a remarkable accomplishment.

However, climate change may limit or even reverse these gains. It will hit the very poor hardest, making it tougher for those in extreme poverty to escape it, and drawing the moderately poor back into extreme poverty. Some climate change is now inevitable. Countries will need even greater ambition, and great support, to adapt and limit impacts on the poor.

But adaptation to climate extremes becomes increasingly implausible, particularly for the poorest, as we move beyond 2ºC global mean temperature rise. Avoiding surpassing 2ºC will require zero net greenhouse gas (GHG) emissions—deep decarbonisation, with any residual emissions offset by GHGs removed from the atmosphere—before the century's end. This too will require prompt, global action: achieving zero net emissions before 2100 will necessitate peaking global emissions by around 2030, the same timeframe forecast for the eradication of extreme poverty.

To achieve zero emissions, and indeed to peak in the next couple of decades, all countries need to transform their economies. Developed countries must make the deepest and most urgent cuts against their current emissions: their emissions peak has passed. If they are serious about eradicating poverty, deep domestic GHG cuts are part of their obligation. But middle and low-income countries must also ensure their current investment choices reduce their forecast emissions, and that they anticipate a rapid peak and decline in emissions as part of their development path.

This presents a global challenge that some argue conflicts with the goal of eradicating extreme poverty. However, early evidence suggests low-emission economic development, although radically different from historic experience, is consistent with the combination of moderate, sustained and pro-poor growth and reductions in inequality needed to eradicate poverty. The impact of unchecked climate change creates an insurmountable challenge for the zero poverty target, but climate change mitigation need not.

This paper finds that the goal of zero net emissions is compatible with eradicating extreme poverty and is, indeed, necessary to sustain such achievement. However, their achievement depends on the nature and quality of growth and how it is achieved over the next decades.

Pathways to zero extreme poverty: sustained, more equal and pro-poor growth

Various projections conclude that the effective eradication of extreme poverty is feasible by 2030. It is, albeit more challenging than the projections lead one to believe. These projections depend on overly optimistic assumptions about the scale of future economic growth, its uniformity across sectors and countries, and impact on poverty reduction. We face 'diminishing returns' in terms of poverty reduction from growth, given the location and structure of the poverty that remains, with more concentrated in states with a poorer record of growth and equity, a more fragile political environment and a less diversified and stable economic structure.

Economic growth is still crucial: a threshold of moderate and sustained economic growth over the next several decades is necessary under nearly all poverty-eradication scenarios, but it is likely to be more moderate and less effective in reducing extreme poverty in the coming decades than many projections suggest. Ensuring we achieve the goal of zero extreme poverty by 2030 will therefore require a reorientation, not simply a replication, of experience over the past two decades. It is also vital to reduce the inequality of the benefits of that growth.

Addressing growth and inequality together is far more likely to reduce poverty than a strategy reliant on attempts to maximise growth alone, based on unrealistic projections. Indeed, extreme poverty could be solved overnight if the inequality of wealth was addressed. Of course, direct redistribution of wealth, through policies like cash transfer programmes, is a partial solution limited to certain circumstances. Nevertheless, it points to the need to ensure that growth is targeted to the improvement in the consumption and productivity of poor people specifically.

1 By most measures, including here, zero extreme poverty means reaching a global rate of extreme poverty of 3% (Ravallion, 2013).

Robust poverty eradication must generate the circumstances in which the extreme poor can productively participate in the macro-economy. Drawing from the work of the Chronic Poverty Advisory Network (CPAN, 2014), we focus on five factors that ensure growth is pro-poor:

- **Boosting human capital**, investing in the nutrition, health and education of poor people.
- **Asset accumulation**, ensuring that improvements in land, livestock, physical capital and credit accumulate to poor people.
- **Improving pro-poor infrastructure and services**, ensuring that investments in infrastructure and services like energy, water and transport are designed to benefit the poor directly.
- **Increasing employment opportunities**, with economic and labour policies designed to create opportunities for the poorest.
- **Enhancing governance and political representation**, ensuring poor people have access to justice and the rule of law, along with mechanisms through which their own expressions of their interests are reflected in public policies.

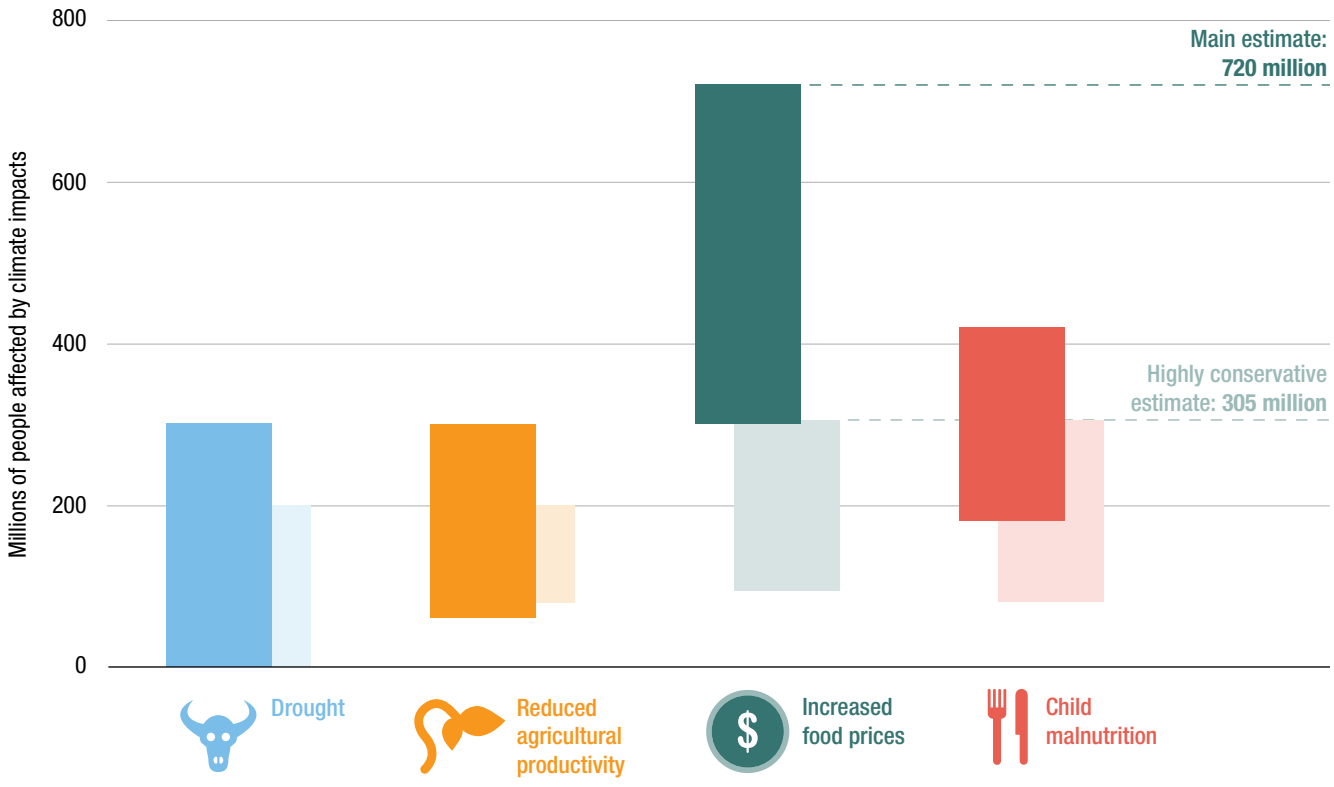
Any poverty reduction strategy will need to consider growth and this broader range of factors that shape whether growth benefits poor people. Sustained, pro-poor growth, even if at more moderate but realistic rates, is likely to provide the best chance of reaching our collective goal of zero extreme poverty by 2030.

The impact of climate change on poverty: the pyrrhic victory of high-carbon growth

The above may provide a road map to poverty eradication by 2030, but sustaining poverty reduction also relies on curbing climate change. Due to historical greenhouse gas (GHG) emissions, the globe is likely committed to global warming of 1.5-2ºC on average before the century's end. Poverty eradication efforts will be slowed, and maintaining them will be harder, unless development ambitions factor in adaptation and resilience-building. Adaptation to climate extremes becomes increasingly implausible, particularly for the poorest, as we move beyond a 2ºC average. Avoiding these catastrophic impacts requires large structural changes to put the world on a trajectory toward global peaking emissions around 2030 and zero net emissions before 2100.

The alternative is that governments do nothing beyond current policies and the climate heads toward 2ºC mean temperature change by 2050 and 3.5ºC by 2100. Under this 'business-as-usual' scenario (BAU), millions of people will fall back into extreme poverty. There is copious research evidencing that climate change from this BAU scenario will impact the world's poor the hardest, but few have tried to quantify the numbers of poor people affected and its impact on poverty eradication targets. To bring home the scale of unmitigated climate change on poverty reduction, we have put together a cautious estimate, synthesising data on only the most quantifiable impacts for the period 2030-2050 on

Figure A: Up to 720 million people are at risk of facing extreme poverty from climate impacts between 2030 and 2050



Authors' calculations based on data from multiple sources (see section 3.2.b for citations and method)
Opaque bars show main estimates; transparent bars show highly conservative estimates.

the extreme poor and those just beyond extreme poverty but at risk of being dragged back in.

Analysing only the most quantifiable impacts under business as usual, we estimate that climate impacts put up to 720 million people at risk of facing extreme poverty from 2030 to 2050 under BAU. This is about the same number of people who exited extreme poverty in the last two decades of record development progress (Povcal, 2015).

These calculations derive from pathways tracing the impact of climate change on just four factors affecting poverty that have the most robust and easily quantifiable evidence (see Figure A): the productivity of primary sectors, food prices, effects on childhood malnutrition and stunting and increased droughts. It is likely that the numbers shown would be much higher if other impact pathways were considered, such as sea-level rise, urban vulnerability, higher incidence of airborne diseases and secondary impacts on child and female education, fertility and conflict. The impacts of climate change will also reduce the underlying economic growth that supports poverty eradication, producing an indirect drag on efforts to eradicate extreme poverty.

Achieving zero extreme poverty on the path to zero net emissions

The above makes it clear that a pathway toward zero net emissions is necessary to sustain poverty eradication. This reaffirms, among other things, the clear need for domestic mitigation by the world's largest emitters and for an international agreement capable of addressing the interdependency of effective climate action. It also positions poverty eradication as a catalyst for more ambitious action on climate change.

However, the achievement of global zero net emissions requires action by countries across all levels of development. While the actions are somewhat different, the time period over which economies must be radically redesigned is not significantly altered by a country's economic status. Even countries where extreme poverty remains will have to move to growth and development strategies anticipating the need for declining emissions from about 2030 if climate change is to be averted.

A zero net emissions pathway may be necessary to avoid exacerbating poverty, but low-carbon development must also be sufficient for poverty eradication if the zero-zero goals are to be compatible. There is mounting evidence that it is.

First, it is important to recognise that many of the most important poverty reduction measures have little to do with emissions. Literal redistribution alone could theoretically eradicate extreme income poverty nearly instantly with little effect on the global economy and equalising policies that temper income inequality may be a necessary condition for eradicating extreme poverty (Greenhill et al, 2015).

All scenarios also require sustained growth. This paper looks at each of the most methodologically robust analyses focused on the two regions that are home to most of the world's extreme poor: Sub-Saharan Africa and Asia.

A set of marginal abatement cost (MACC) analyses show at least the first 15-30% of emissions reductions compared to BAU between now and 2035 are growth enhancing. Figure B shows these growth enhancing measures would get us much of the way toward the emissions reductions compatible with a zero net emissions path based on our

Table A: Key climate mitigation actions and their impact on the livelihoods of the extreme poor

Mitigation action	Distribution related impact on the extreme poor
Climate-smart agriculture practices	Direct increase of agricultural productivity and income for those in extreme poverty. Direct increase in the value of land for poor land-owners. Increased resilience and reduced risk of large income fluctuations.
Increased public transport	Reduction in health-related costs from air pollution. Greater mobility at lower cost, which expands employment opportunities and net benefits.
Low-emissions waste management	Reduction in health-related costs from poor sanitation.
Reduced subsidies for fossil fuels and fertiliser	Increase in the income of those in extreme poverty due to better-targeted technical and cash transfers.
Distributed renewable energy (electric and household thermal)	Reduction in health-related costs from indoor pollution. Access to energy at lower cost than high-carbon alternatives.

calculations from IEA and IPCC data. However, these are 'incremental' analyses that look only at emissions reductions in existing sectors with no structural change to the economy.

Analysis that considers transformation of major systems, like energy, project that such measures reduce emissions by one-third compared to BAU and improve GDP by 3.9% in India, 2.4% in Indonesia, 2% for least-developed African countries, 1.4% for China and 1.6% for other ASEAN countries, although one earlier outlier study showed a 3.3% decline for India (IEA, 2012).

The above analyses do not consider economic impacts not factored in by the market but easy to estimate the economic value of, such as reduced illness and death from air pollution. Once these are included, the benefits of low carbon growth rise even higher. The recent New Climate Economy Report concluded that up to 50%, and possibly up to 90%, of the emissions reductions required by 2030 could be achieved at no cost to economic growth, when considering both co-benefits and a wider range of 'transformational' approaches. A recent World Bank study found India and China's emission could be reduced by nearly a third at no or 'negative' costs in two sectors alone—energy efficiency and clean transport—when improved air quality was taken into account (Akbar et al., 2014).

A few studies estimate that moving to a net zero emissions pathway will have a potential negative impact on growth rates or, at best, provide a low positive impact on growth rates up to 2050 compared to BAU.[2] This is equivalent to the loss of only 6 to 24 months of economic growth by 2030 compared to BAU, too small a cost to place a major check on well-targeted poverty eradication efforts. In addition, these studies may overestimate the impact of slowing growth rates compared to BAU, as they ignore the economic costs of climate impacts in that period (New Climate Economy, 2014).

The compatibility of pursuing low carbon growth with eradicating poverty is reinforced when considering that poverty eradication is also crucially about the structure and equality of growth, and not merely its magnitude. Aside from their impacts on national-level economic growth, positive or negative, individual climate actions can have many direct benefits for poor people, whether improving their productivity, enhancing their access to public services or reducing their exposure to pollution. These goals are crucially about the quality of growth. If the goals of zero net emissions and zero extreme poverty are considered together by policy makers, a low-carbon pathway can support a reorientation toward the more pro-poor growth that will be required to ensure poverty eradication by 2030. Achieving this will require institutional and technical capacity, as well as financing, with a focus on programmes and investments for the poor, Table A sets out some key actions to mitigate the impact of climate change, their impacts on the poor (i.e. 'distributional impacts'), and how to make these actions pro-poor.

Policy implications

The international development community needs concrete and discrete development priorities in order to direct a critical mass of attention and direction to the biggest global challenges. Poverty and development are complex and multidimensional, reflected in the breadth of the proposed Sustainable Development Goals. However, we are rich in nuance and poor in focus. This report emphasises lasting poverty eradication as both the moral minimum floor of our development effort and challenging to achieve, all the more so in the face of the climate crisis.

To achieve lasting zero poverty, development efforts must be more pro-poor and low-emission. In policy terms, this implies that:

- **Poverty eradication is possible by 2030, through growth and reductions in inequality.** Economic growth in developing countries is crucial for poverty eradication, but it is not enough. Addressing growth and inequality together is far more likely to reduce poverty, requiring targeted measures that focus on the building poor people's human capital (through nutrition, health and education), their opportunity to accumulate assets, their access to infrastructure, services, and jobs, and political representation. It will also need to contend with the impacts of climate change.
- **Poverty eradication cannot be maintained without deep cuts from the big GHG emitters.** It is policy incoherent for big GHG emitting countries, especially industrialized countries, to support poverty eradication as a development priority, whether through domestic policy or international assistance, while failing to shift their own economy toward a zero net emissions pathway. Developed countries that want to show leadership in fighting extreme poverty globally need to cut domestic emissions to deliver on their ambition, and also redouble their efforts to support developing countries achieve low-carbon, resilient development.
- **Low emissions development is both necessary for, and compatible with, poverty eradication.** Emerging economies need to plan for peaking emissions and a zero net emissions target. There is an increasing body of evidence showing that many, if not most emissions reductions opportunities in developing countries are actually growth enhancing. The size and timing of emissions reductions is subject to considerable debate, often related to what constitutes a 'fair' division of responsibility between richer and poorer countries. The need for international support for many developing countries remains of high importance, *but this is true of BAU and low-carbon growth alike*. The issue is whether development ambitions are orientated towards a low-carbon pathway to lasting poverty eradication or a BAU pathway to poverty reduction that may be, at best, temporary.

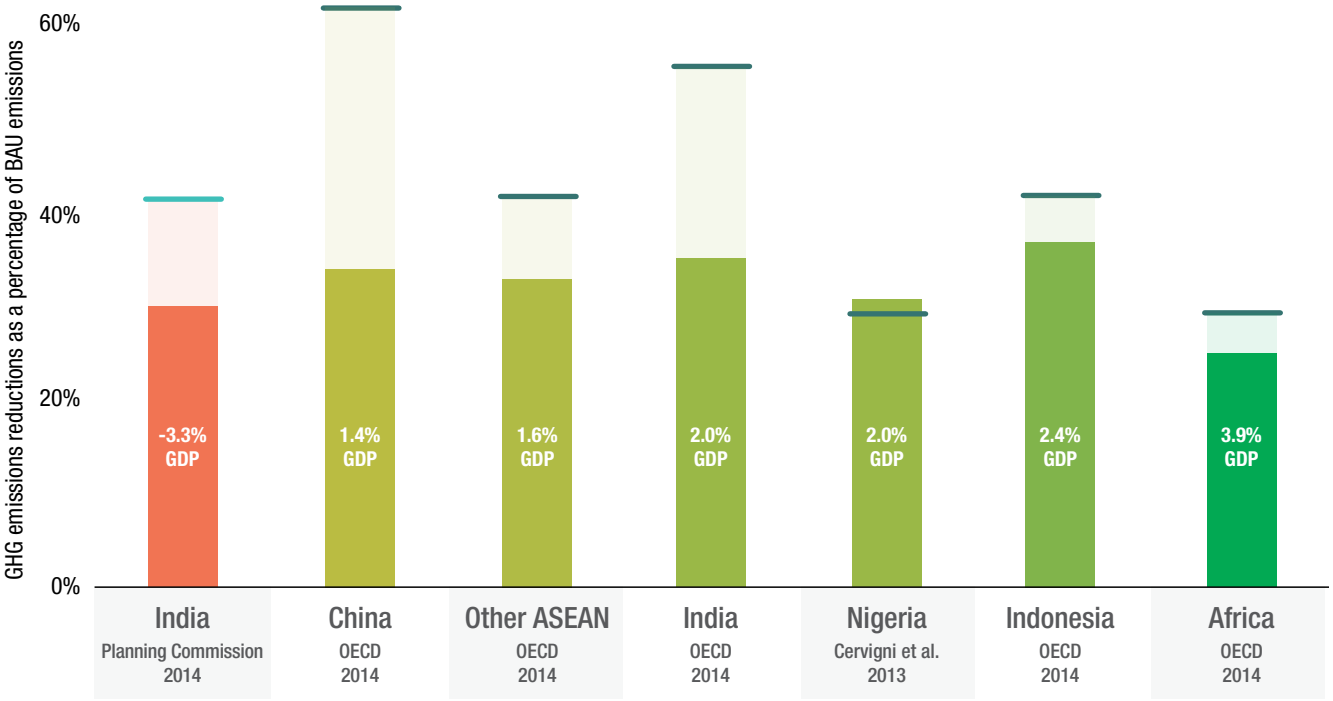
2 Some macroeconomic studies of the impact of moving to a net zero emissions pathway on growth up to 2050 tend to estimate cumulative impacts of +1% to -3% of GDP over this period compared to BAU.

Figure B: Most of the GHG emissions reductions in developing countries are growth enhancing

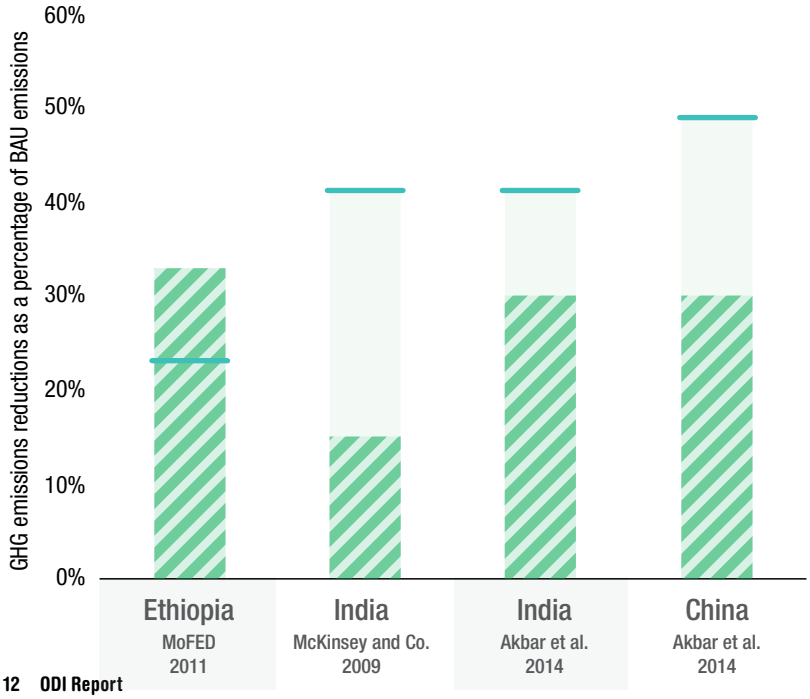
Most GHG emissions reductions in developing countries are growth enhancing

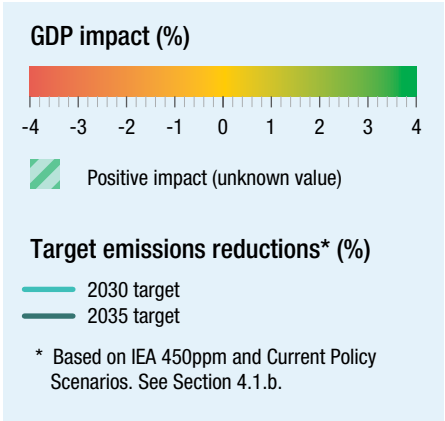
Analyses of developing Asia and Africa show that the low-emissions development necessary in the next two decades for a zero net emissions pathway is growth enhancing. The six most robust studies are shown below grouped by methodology, with estimated growth impact indicated where available.

Sector and macroeconomic studies incorporating transformational change



MACC analyses of incremental changes to existing sectors with no structural change to the economy





1. Introducing the Zero Zero challenge

1. Getting to zero extreme poverty is within our reach

For the first time, it is possible to envisage the eradication of extreme poverty within a single generation. Lifting the one billion[3] people living on less than $1.25 a day out of extreme poverty is expected to be the first goal of the Sustainable Development Goals (Open Working Group of the General Assembly on Sustainable Development Goals, 2014), and the cornerstone of the World Bank's vision (World Bank Development Committee, 2013).

Global progress in reducing poverty over the past two decades gives us grounds for some optimism. Between 1990 and 2011, extreme poverty – measured narrowly as the percentage of those living on less than $1.25 per day[4] – fell by almost two-thirds, from 43% to 17% of the population of the developing world (Povcal, 2014). This exceeded the Millennium Development Goal (MDG) target: halving extreme poverty rates by 2015. Looking beyond income poverty, we see that enrolment in primary education in developing regions reached 90% in 2010 (UN, 2014a), maternal deaths dropped by 45% between 1990 and 2013 (UN, 2014b), and 2.3 billion people gained access to improved drinking water sources between 1990 and 2012 (UN, 2014c); all important components in the reduction of impoverishment.

This progress has situated the global community in range of the 'zero zone' (Elliott, 2013), where less than 3% of the world's population live on less than $1.25 per day. Projections suggest that this 'effective eradication' (Ravallion, 2013) of extreme poverty is possible by 2030 – at the end of the next round of global development goals.[5] Effective eradication overlooks those who are hovering just above the poverty line, along with dimensions of poverty other than income. Nevertheless, the realisation that the effective eradication of extreme poverty is plausible creates an ethical momentum to achieve such eradication as a political priority. Extreme poverty likewise represents such a low level of consumption that, even when set alongside other laudable goals for improving human welfare, it seems to represent a minimum ethical floor for our development efforts. At the same time, it is one of the few Sustainable Development Goals we could be on track to achieve (Nicolai, et al., 2015).

2. Getting to zero emissions requires transformative actions in all economies over similar time periods

If the global community is serious about eradicating extreme poverty for good, it needs to think beyond 2030. Eradicating poverty by 2030 will be no great accomplishment if we are incapable of sustaining that achievement from 2030 onwards. Whether we tackle the climate crisis in the coming decades, and in particular head toward zero net emissions, will largely determine whether our achievement of poverty eradication represents a lasting accomplishment or a Pyrrhic victory, in which the means of our success causes its own undoing.

Climate change increases the probability that those who emerge from extreme poverty will be at risk of falling back into it. There is a growing realisation that poverty goals will need to be more ambitious in the light of climate change, so this does not happen. Climate impacts are already hitting the poorest people hardest, as they have the greatest exposure to climate-sensitive sectors and are more vulnerable to its impacts (IPCC, 2014b). The threats include increases in the severity and frequency of climate shocks amplified by the greater frequency and magnitude of weather and climate hazards as driven by greenhouse gas (GHG) emissions (Gutierrez et al., 2014).

3 Most recent estimates are for 2011 from PovcalNet.

4 Measured at 2005 international prices adjusted for purchasing power parity (PPP).

5 Even under the most optimistic projections showing the goal of zero extreme poverty could be met by 2030, 3-7% of the world's population, or 200-300 million people, would still remain in extreme poverty. Extreme poverty will be increasingly concentrated in fragile states and/or sub-Saharan Africa, with rates expected to remain high in these regions in 2030 (Greenhill et al. 2015). For example, in sub-Saharan Africa, this would still leave around 20% of the region's population living below $1.25 a day.

A target of near zero GHG emissions by 2100 has been identified by the recent 5th Assessment Report of the IPCC as being necessary to nearly all scenarios that hold the global mean temperature rise below 2°C (IPCC, 2014c). A 2°C rise in global temperature is seen as the limit beyond which the world will face 'dangerous anthropogenic interference' (UNFCCC, 2009). Although the validity of the 2°C target and its use in negotiations has been debated (Victor and Kennel, 2014), it is clear that beyond 2°C, the world is likely to experience irreversible and catastrophic climate events and global damages (IPCC, 2007).

These mitigation scenarios make it merely 'likely' (>66% probability) that we will hold the global mean temperature rise to only 2°C. Studies exploring emissions pathways that could lead to greater probability of achieving this temperature range, or even a 'more-likely-than-not' chance of limiting global mean temperature rise to 1.5°C, are limited (IPCC, 2014c). Given the massive negative impacts on human life of even the 2°C scenario, there is a strong case for adopting more ambitious mitigation pathways. However, there is less scientific and political buy-in behind these. Furthermore, the mitigation pathways for both levels of ambition are remarkably similar – requiring global emissions peaking near 2030 – necessitating the same urgency of action. This requires action well within the lifetime of the existing infrastructure and 2030 zero extreme poverty goal.

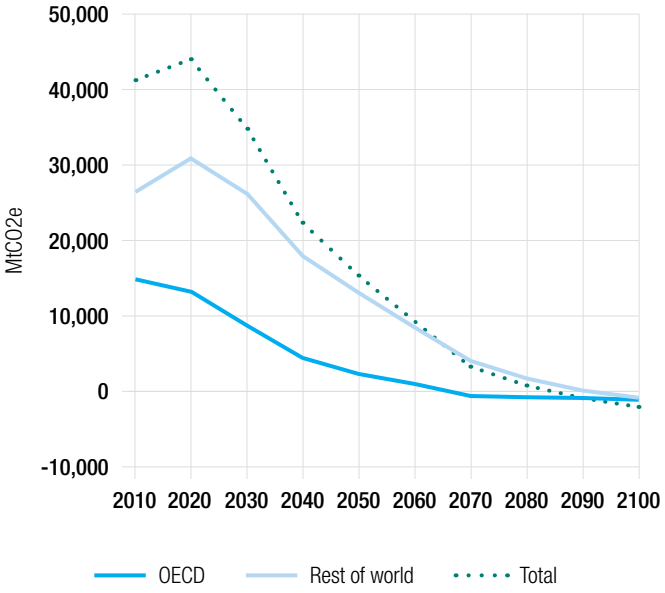
3. Zero net emissions must therefore be part of the zero extreme poverty agenda

Given that an increase above 2°C will make it hard to reach or maintain global poverty objectives, all realistic chances of reaching and remaining in the zero zone require us to meet the 2°C target.

It is sometimes argued that the high cost of climate mitigation brings it into direct conflict with the goal of poverty eradication. For richer countries, the burden of supporting climate mitigation in developing countries is seen by some as a source of competition for the limited resources available for poverty eradication. For poorer countries, it is argued that mitigation action will harm economic growth and therefore slow progress on poverty eradication, with countries having to choose between the two.

A growing body of evidence, synthesised in the New Climate Economy Report (NCE, 2014), contradicts this view. It affirms that low-carbon growth, through 2030 and beyond, can make better economic sense than growth based on business as usual (BAU). Although rich countries must mitigate their emissions sooner and faster, they now appear unlikely to face an economic cost significant enough to justify a reduced commitment to support for poorer countries in both their mitigation and poverty eradication efforts. In addition, the early evidence discussed in this paper suggests domestic mitigation in countries with populations of extremely poor people could well have

Figure 1: Countries must collectively reach zero net emissions in 2100, but have different peak emission points



Source: Zero net emissions scenarios based on IEA WEO Current Policies scenario and IPCC RCP2.6 scenarios with concentrations of 450ppm in 2100.

synergies with poverty goals. These synergies and their potential trade-offs need to be much better understood if we are to follow an efficient pathway to zero net emissions and zero extreme poverty.

However, even if mitigation action puts us on a trajectory to achieve the 2°C goal, climate change will still pose a challenge to the eradication of extreme poverty. Even under the most optimistic and dramatic scenarios of GHG emission reductions, the world is still locked into global warming caused by historical emissions; in the short term we are already committed to average warming of 1.5°C by 2030 (IPCC, 2014c). Because 'global mean temperature rise' represents an average, some areas will experience greater warming and its associated impacts. Some regions also have communities, ecosystems and production systems that are very sensitive to even small changes in weather and climate. Even at current levels of warming, the greater frequency and severity of extreme weather and climate events are having impoverishing effects (IPCC, 2014c; Shepherd et al., 2013). There are also limits to adaptation, and 'residual' damages – those that cannot be adapted to – could place even greater burdens on poor people. In general, modellers projecting poverty eradication continue to omit these climate-related factors.

The realisation that climate change makes people near global poverty lines vulnerable to falling below those lines has led researchers to seek to identify a threshold at which people emerging out of poverty are likely to stay out. Setting 'impoverishment lines' or 'resilience to poverty lines' relates to the blend of income and assets

that are most likely to protect people from a fall back into poverty when faced with a shock, such as a drought or high food prices (Shepherd et al., 2013). There is, as yet, no global dollar-equivalent representing resilience to poverty or a simple dollar amount that corresponds to climate resilience—it will depend on income, assets, capabilities, agency and external factors such as security and governance. However, it is clear that anyone living on close to $1.25-per-day, in 'extreme poverty', is already enduring a level of consumption that is far too low to be capable of such resilience. This means we must be even more ambitious about our poverty goals in the context of climate change. This is not only because 'zero net emissions' must be part of our anti-poverty agenda, but also because enabling poor people to move 'to and through' $1.25 a day is a prerequisite for the sustained eradication of extreme poverty in light of climate change. An income-based resilience line can be a useful foundation for the re-assessment of our extreme poverty goal. This paper uses $2-a-day 'moderate poverty' as a conservative approximation to generate a 'poverty resilient' combination of income and assets, which also aligns with the World Bank's definition of moderate poverty (Povcal, 2014), although a precise dollar amount for resilience is likely to be far higher.

In short, without radical and ambitious changes to GHG emissions trajectories, and a scaled-up effort to build the resilience of poor people to the impact of climate change, sustaining zero extreme poverty will be impossible.

4. Pathways to Zero Zero

What options already exist to achieve the goal of zero extreme poverty by 2030? What options surpass the poverty eradication goal sufficiently to ensure poor people stay above the global extreme poverty line? What options are compatible with achieving zero net emissions by 2100, to ensure the climate crisis does not unwind our achievements? How do we ensure global emissions peak in the next 15 years, while we are on the path to zero extreme poverty?

This paper aims to provide a critical analysis of current approaches to poverty eradication and a review of not only the implications of climate change, but also what is needed to manage the risks it presents.

It focuses on the scope for synergy between poverty reduction and low emissions pathways as well as domestic development policy choices. It also notes that the domestic actions of richer countries remain critical and influential on the opportunities for sustaining zero extreme poverty and mitigating climate change. The domestic actions of richer countries will influence the opportunities for sustaining zero extreme poverty in poorer countries, and these actions have rightly received much attention. This report takes the conversation further; to reach the twin goals will require identifying the potential synergies between poverty reduction and low-emissions pathways in countries with significant populations in extreme poverty (and, implicitly, on the development policy priorities of richer countries supporting eradication of such poverty). This will then pave the way for a more comprehensive discussion about the more ambitious development pathway needed to achieve and maintain the eradication of poverty in the face of a changing climate.

Section 2 explores the likelihood of eradicating poverty by 2030 by analysing the main projections of falling poverty rates. It then reconsiders the assumptions on which these projections rely, focusing on more moderate, and perhaps more realistic, growth projections combined with reductions in the inequality of growth across income groups. It also identifies likely elements of a sustained scenario of zero extreme poverty, concluding that moderate and sustained economic growth accompanied by reductions in the inequality of that growth is the most realistic pathway toward the goal of zero extreme poverty.

Section 3 considers the impact of climate change on extreme poverty and its key implications for a zero extreme poverty goal. It does so by using two well-analysed scenarios: a BAU emissions pathway in which we do nothing beyond current policies, and one that has the target of zero net emissions by 2100, needed to avoid the worst climate extremes. The climate-related risks posed to poverty eradication are explored by reviewing the impacts of economic growth and calculating new estimates of the number of poor people likely to be impacted directly by climate change. The section also considers how adaptation can help avoid the impact of climate change on those who are vulnerable to extreme poverty, as well as the scope of residual damages where adaptation is not plausible.

Section 4 explores the evidence that pathways towards zero net emissions are consistent with poverty eradication goals. It finds a substantial body of early evidence showing significant scope for both growth-enhancing and poverty-reducing low-carbon development choices. It also indicates that even more costly emissions reductions are still consistent with the moderate and sustained growth necessary for poverty eradication. This evidence suggests that a low-carbon economy moving toward zero net emissions is, at worst, fully compatible with, and indeed likely to be better at, achieving the moderate and sustained growth and reductions in inequality of growth necessary for zero extreme poverty. It is certainly far more compatible with sustained poverty eradication than BAU. This section also discusses transitions in energy, agriculture and human habitat. This is to give context to the economic shifts being discussed and consider the opportunities and challenges for synergy between the two zero zero goals during this transition.

Section 5 provides brief conclusions about both the central challenges and feasibility of achieving zero extreme poverty and zero net emissions.

2. Achieving zero extreme poverty

1. Why aim for zero extreme poverty by 2030?

The eradication of poverty by 2030 has become the chief goal in the international development arena. It is a cornerstone of the World Bank's agenda (World Bank Development Committee, 2013) and headlines the Open Working Group's Proposal for the Sustainable Development Goals submitted to the UN General Assembly (Open Working Group of the General Assembly on Sustainable Development Goals, 2014). It is also the subject of a growing activist campaign (Global Poverty Project, 2013).

The rapid global progress made on poverty in recent decades is the basis for some optimism that zero extreme poverty can become a reality. Between 1990 and 2011, extreme poverty decreased by almost two-thirds, from 43% to 17% of the developing world's population. While this progress was not even—most poverty reduction occurred in East Asia, with 80% of the remaining poor concentrated in sub-Saharan Africa and South Asia— it was nevertheless remarkable (PovCal, 2014). Based on these trends, prominent development economists such as Martin Ravallion and Laurence Chandy have suggested 'effective' poverty eradication is possible by 2030. Their projections are, by nature, narrow in their assumptions (Box 1). They tend to:

- focus on extreme income poverty (measured as less than $1.25 per day) rather than a broader or multidimensional measure of poverty (Box 2)
- assume uninterrupted decades of high growth rates
- presume inequality will remain unchanged over time (Ravallion, 2013; Karver et al., 2012; Chandy et al., 2013; Edward and Sumner, 2014).

Even with such narrow assumptions, economists who project poverty rates tend to make caveats along the lines of Chandy et al., who assert that predicting extreme poverty decades into the future is somewhat of a 'fool's errand' (Chandy et al., 2013).

Nevertheless, these projections, showing a high degree of consistency (Figure 2), have helped to galvanise international development and focused attention on the fact that the eradication of extreme poverty is not a fool's errand by any means.

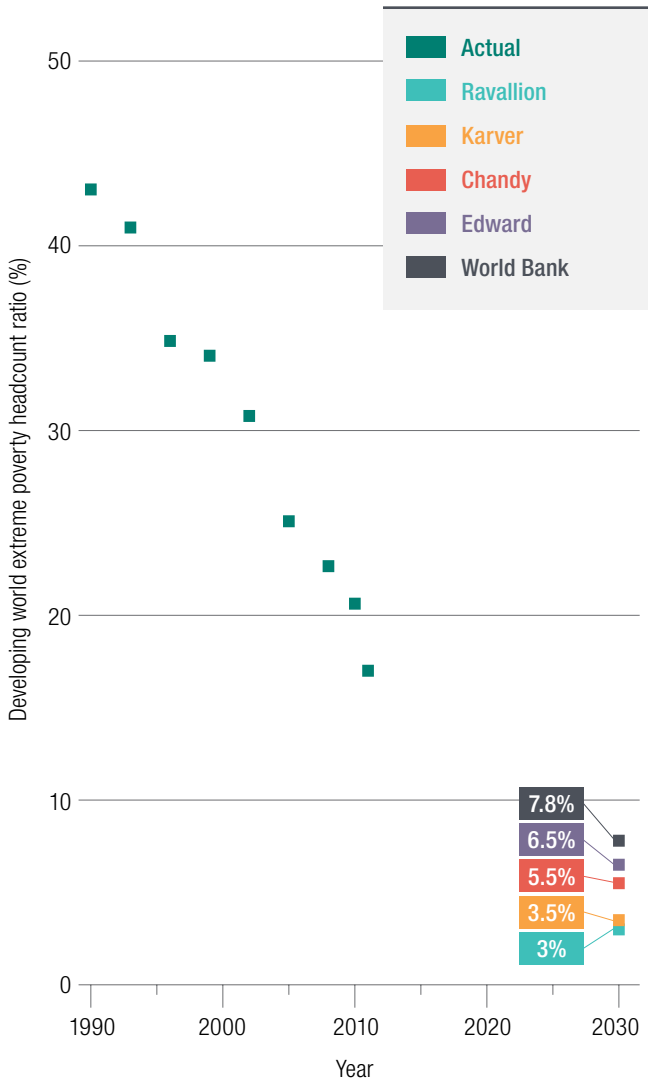
2. The role of economic growth in projections of zero extreme poverty

Under most projections, economic growth is required to reach effective extreme poverty eradication by 2030. This is true of projections that assume high growth and hold other variables constant (like those discussed above) and those that consider possible changes according to other factors, such as inequality (such as Woodward, 2013, discussed further below). The fact that maintained growth at some level is necessary for poverty reduction is evident when considering the counterfactual: a major contraction of the global economy would make it difficult for the countries affected to expand the consumption of their poorest people through domestic policy choices. It would also make it more difficult—politically and practically—for developed countries to support such activities through expanded trade and development assistance.

Growth creates additional wealth and jobs, which helps to fuel poverty reduction. The dramatic reduction in poverty over the past two decades has occurred alongside the fastest period of growth the developing world has ever seen (Bolt and van Zanden, 2013) and the growth economies in East Asia have been a major factor in their success in poverty reduction. While there may be limits to the role of growth in poverty reduction, which are discussed further in this section, there is no question that it has contributed significantly to large-scale improvements in the wellbeing of poor people in absolute terms.

However, growth will also need to be sustained to ensure that the achievement of zero extreme poverty endures. This is because lifting the consumption of poor people to just above the extreme poverty line is not enough to eradicate extreme poverty forever. While the number of people living on below $1.25 a day has declined over the past two decades, those living on between $1.25 and $2 a day has remained the same (PovCal, 2014). The median income for the developing world only shifted from below $2 a day to slightly below $3 a day between 1990 and 2011 (PovCal 2014). Initial analysis suggests that even

Figure 2: Projections by major economists of the extreme poverty rate in 2030 (%)



under exceedingly optimistic assumptions, whereby the developing world economies grow at 4% per capita over the next 20 years and inequality remains constant, almost 10% of the world's population would still live below $2 a day in 2030, as shown in Figure 3 (PovCal, 2014).

People living just above the poverty line are very vulnerable to falling below it (Hulme et al., 2001; Yemtsov, 2013; Suryahadi and Sumarto, 2003; Adelman et al., 2014; Calvo and Dercon, 2012; Samman, 2013; Pritchett et al., 2000; Christiaensen and Subbarao, 2005; Chaudhuri, 2003; de la Fuente et al., 2014; Dang and Lanjouw, 2014). Being 'vulnerable' has been defined by some authors as having at least a 10% chance of falling back below a poverty line (de la Fuente et al., 2014; Scott et al., 2014). While no agreed number exists for what 'line' constitutes being 'vulnerable' to extreme poverty, it is highly likely that it would be well in excess of $1.25 a day. The need to lift people out of vulnerability and sustain that gain means moving poor people to and through $1.25, to some higher and more resilient combination of income and assets. The issue of vulnerability becomes all the more prominent when the impacts of climate change are considered, and is discussed at greater length in Section 3.

3. Zero extreme poverty can't be achieved through economic growth alone

While growth is unquestionably part of reaching zero extreme poverty, relying on high growth rates alone to achieve this goal would be unwise.

First, recent high growth rates may not be sustained. Projecting them decades into the future paints an overly optimistic view of extreme poverty in 2030. Poverty rates are highly sensitive to growth rates; projections of poverty eradication will be derailed if current growth rates are not sustained, assuming all else equal (Greenhill et al, 2015). For example, if global growth slows by just three percentage points, an estimated additional half a billion people will be living in extreme poverty in 2030 (10% of the developing world's population), pushing the achievement of the 3% global poverty goal back by more than 30 years (Ravallion, 2013).

These lower than projected growth rates could well be the reality. A recession at any point within the next 15 years, for example, would side-swipe reductions in extreme poverty, as seen during the Asian Financial Crisis in 1997 (World Bank, 2014b; PovCal, 2014). In addition, the recent economic slowdown in the developing world has not been factored into most of the projections, as the bulk of them were produced in 2012 (IMF, 2014). The latest estimates by the World Bank, released in October 2014, show that, based on the most recent growth rates, reaching the 3% poverty goal by 2030 is almost impossible (World Bank and International Monetary Fund, 2014) and that a global extreme poverty rate of 7% or higher in 2030 is likely.

Second, growth has had different effects on poverty reduction in different regions and countries, often depending on such factors as the sectors driving that growth. It has, for example, led to relatively little poverty reduction in sub-Saharan Africa. Even though the region has the highest number of poor people and the highest incidence of extreme poverty in the world, growth in sub-Saharan Africa has not been correlated strongly between the non-poor[6] and poor (PovCal, 2014). The strength of the relationship between growth for the poor and non-poor in sub-Saharan Africa has been lower than in either East or South Asia (Figure 4) (Chandy et al, 2013; PovCal, 2014). This has significant implications when considering the role of growth in being able to lift people out of poverty in the future.

6 Non-extreme poverty is defined as living above $1.25 a day.

Box 1. Projections of extreme poverty in 2030

The different approaches to estimating future poverty rates tend to fall into three main categories:

- projecting future levels of growth and inequality based on historical changes in GDP per capita and inequality (Edward and Sumner, 2014);
- estimating semi-elasticities of how changes in growth have corresponded with changes in poverty using historical data;
- using complex models that factor in the interaction of hundreds of variables based on historical trends.

The first method is most commonly used in the literature and will be the focus of this paper. While the other approaches are credible, they have not gained wide acceptance. The use of semi-elasticities of poverty on growth is considered to be less relevant over longer time periods and complex models are often not overly transparent, which can generate scepticism over their reliability (Edward and Sumner, 2014).

A main difference between the most commonly cited studies that fall into the first category is the data used as the basis for projecting growth into the future. Chandy et al. (2013) rely on growth forecasts from the Economist Intelligence Unit, while Karver et al. (2012) use pre-financial crisis IMF forecasts of economic growth. Edward and Sumner (2014) follow the same methodology, but use updated data. Ravallion (2013) uses historical growth rates from the 1980s and 1990s as the basis for his pessimistic scenario and growth rates from the 2000s for his optimistic scenario. All of the projections are either directly or indirectly based on historical data because even forecasts are somewhat linked to recent trends.

While these projections of extreme poverty are often cited, they have also been criticised. Most notably, researchers at the World Bank have questioned the analysis in Ravallion (2013) for being overly optimistic (Yoshida et al., 2014). The projections in Karver et al. (2012) may not be credible due to the use of pre-crisis forecasts. Chandy et al. (2013) have not attracted as heavy criticism, however since publication, there has been a slowdown in growth, which is likely to lead to a higher rate of poverty in 2030 than they predicted (IMF, 2014). Edward and Sumner (2014) are careful not to identify a most likely outcome and instead provide a number of scenarios, based on different assumptions.

The projections presented in this paper, whether for better or for worse, played an important role in highlighting the feasibility of the 'Zero Poverty' goal. Therefore the findings of these projections will be discussed in detail, despite questions having been raised about their credibility.

Simply projecting recent growth trends forward over long time horizons does not factor in the sectors driving growth and is a poor foundation for expectations on poverty reduction. Prolonged periods of growth over recent decades have tended to be driven by increased agricultural productivity, allowing surplus labour to shift towards the manufacturing sector, as in China (Knight, 2007; Islam and Yokota, 2008; Ravallion, 2008). However, growth in many other developing countries over the past decade has been driven by the booming commodity prices that have fuelled extractive industries, as opposed to any underlying sustainable transformation (IMF, 2012). For example, GDP per capita has skyrocketed in the richest country in Africa, Equatorial Guinea, as a result of oil exports. However not only is this unlikely to be sustained, it has not led to significant improvements in human development (Malik, 2014).

In reality, economic growth has become increasingly less effective at reducing poverty because of the increasing inequality of that growth. Since 2005, inequalities have widened even further in developing countries, leading to lower rates of poverty reduction than would have been the case if inequality had remained constant (Ravallion, 2013; Yoshida et al., 2014). The inequality of growth directly hampers poverty reduction for simple mathematical reasons: it takes far greater average growth across the economy to translate into income growth for poor people because the rate of growth for them is lower than that for the national average. To reconsider a popular metaphor: a rising tide may lift all boats, but anyone who knows about tides knows they rise to different heights in different places.

4. Addressing inequality is key to achieving the goal of zero extreme poverty

A realistic pathway to poverty eradication requires a threshold of sustained and at least moderate economic growth combined, crucially, with a focus on simultaneous reductions in the inequality of growth rates across income groups. Such inequality of growth must be addressed if the goal of zero extreme poverty is to be achieved by 2030, given that poverty is reduced faster when poor people benefit more from growth. The same level of poverty reduction is possible even if growth rates are more moderate (and realistic), as long as a larger share of growth accrues to those in extreme poverty.

As with economic growth in general, the rate of extreme poverty is very sensitive to the equality of growth. Chandy et al. (2013) show that reducing inequality can have just

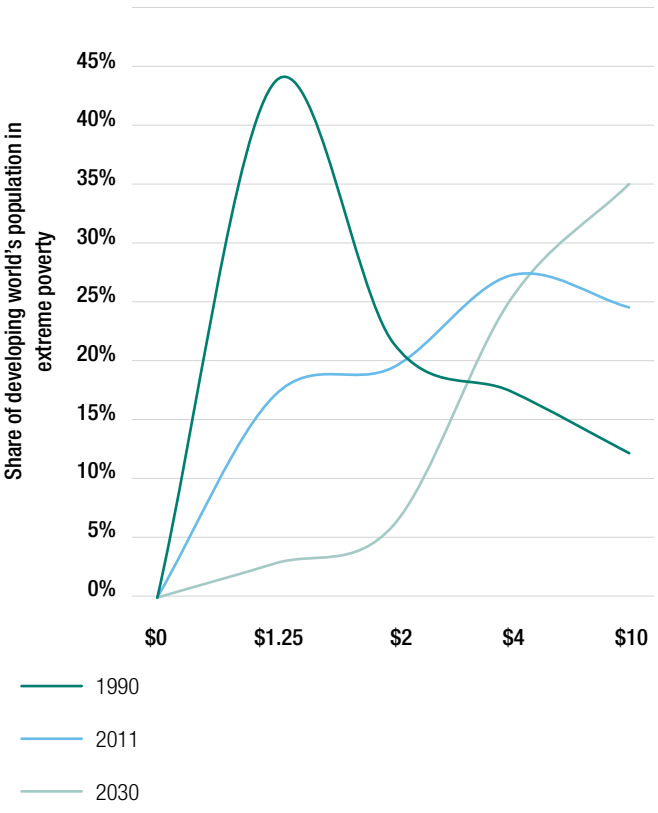
Box 2. Multi-dimensional poverty

At a minimum, permanently eradicating extreme poverty will involve raising everyone's level of daily consumption above $1.25 (measured at 2005 international prices adjusted for purchasing power parity (2005 PPP)) and keeping it above this line into the future. Poverty assessed in such material dimensions— income or consumption, such as the $1.25-a-day measure—are common and useful single measures. They are unable, however, to capture a full picture of either economic poverty, or other non-economic dimensions to poverty, for example whether people are in poor health, feel powerless or lack political freedoms.

The Millennium Development Goals (MDGs) and the 2001 World Development Report highlighted the need for broader poverty measures; the latter also expanded the notion of poverty to include vulnerability and exposure to risk. The Human Development Index (HDI), measuring progress in health, knowledge and income, was also created to emphasise that people and their capabilities should be used when considering the development of a country, rather than economic growth alone. The Multidimensional Poverty Index (MPI) is another tool to measure multidimensional poverty that was introduced in the Human Development Report in 2010. Intended to complement income-based indices of poverty, it is based on 10 vital items that are weighted according to their importance, and gives both the headcount of multidimensional poverty and its intensity. Comparing the MPI index with estimates of consumption poverty, it can be seen that 1.5 billion people were considered to be multidimensionally poor, compared with a 1 billion people living on less than $1.25 per day.

Notwithstanding the broad acceptance that poverty is multi-dimensional and the emergence of various tools against which it can be measured, there remains academic debate on the particular approach, relating to the choice of dimensions and how to weight and aggregate them. Most analyses of poverty start with a consideration of poverty in monetary terms, but recognise that a consumption focus is not sufficient for pro-poor policy design. There is a risk that the consumption non-poor who are poor in other poverty dimensions are excluded, and the consumption poor who score highly in other dimensions are included. A multidimensional approach to poverty is, therefore, critical in the design of the tools and required social programmes to be put in place to eradicate extreme poverty.

Figure 3. Changes in the global consumption distribution from 1990-2030



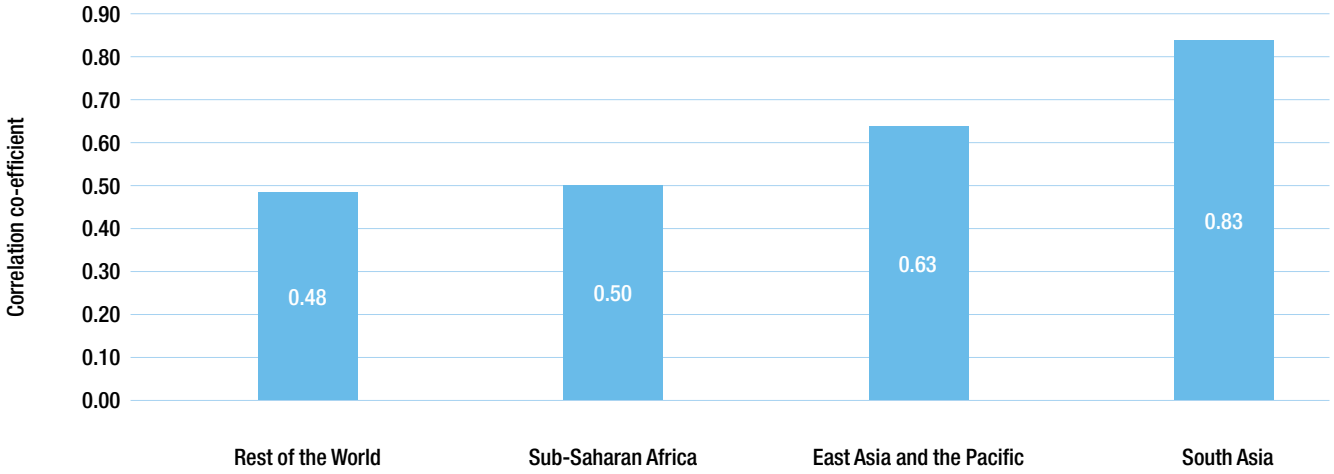
Source: PovCal, 2014

as large an impact on poverty reduction as growth. The extreme poverty rate in 2030 could be up to three times higher in projections based on less equal distributions of growth compared to those based on more equal projections (World Bank, 2014e).

Poverty reduction depends on a growth in consumption among those living in extreme poverty. If there are high growth rates for poor people, significant numbers of them can emerge from extreme poverty, regardless of the magnitude of the overall growth rate. For example, while recent average growth rates in India have been higher than in Bangladesh, poor people in both countries have experienced similar growth rates (PovCal, 2014; Figure 5) because poor people in Bangladesh have gained a larger share of growth than poor people in India.

Woodward (2013) attempts to quantify the time it would take to effectively eradicate poverty without directly addressing inequality. Using assumptions similar to the projections above, he calculates that—based on recent growth rates—it would take over a century for these people to escape from extreme poverty. This would entail the world economy growing by 1500%. He then shows how more modest improvements of the share of growth for the poorest people relative to the mean can greatly reduce the amount of growth and time it would take to lift the poorest people out of poverty (Woodward, 2013). The World Bank's most recent estimates suggest that the only way to reach the goal of zero extreme poverty is if inequality is strongly addressed. They show that even under a very optimistic growth path, the consumption of

Figure 4. Correlation between changes in consumption of the poor and non-poor



Source: PovCal, 2014

the bottom 40% of the distribution would need to grow at least two percentage points faster than average growth in each country for the next 15 years for the achievement of a 3% global poverty rate (World Bank and International Monetary Fund, 2014). World Bank Chief Economist Kaushik Basu maintains that addressing inequalities head on will be crucial. This is one reason why the World Bank has adopted the goal of shared prosperity (Basu, 2014).

5. What does more equal growth look like?

Theoretically, a very low global growth rate—a fraction of 15—would be enough to eliminate poverty if all the gains from growth were to accrue to those in extreme poverty. Even though one-seventh of the world's population live in extreme poverty, they consume less than 1% of global GDP (World Bank, 2014b; PovCal, 2014; Woodward, 2013). This highlights the way in which growth directly benefiting those in extreme poverty could be very effective in eradicating poverty, even in a context of weaker overall growth rates. In fact, evidence suggests that East Asia's historic poverty reductions in the last several decades were largely due not to overall growth, but policies targeting expansions of opportunity and growth for the poorest, particularly in rural areas (Ravallion, 2008).

The reality is that poor people have rarely benefited as much from growth as those who are non-poor, as shown in Figure 6. On average, consumption of the non-poor has grown by almost 3% a year, while that of poor people has grown less than half a per cent.[7] This increases levels of inequality.

Broadly speaking, more equal distribution of growth and greater distribution to poor people, in particular, can be achieved by equalising public policies that help poor people benefit more from, and make a larger contribution to, the activities that contribute to growth. 'Equalising policies' mobilise public revenues that enable poor people to consume more goods and services. In the simplest terms this can include literal redistribution through cash transfers, but it also includes public investments in other goods and services – education and health, for example – that are designed to benefit poor people. Equalising policies include, however, the full range of public policy interventions that make the benefits of growth more widespread. Equalising policies are a pre-condition for more equitable growth, as it enhances the economic productivity of poor people and allows them to increase their participation in the formal economy.

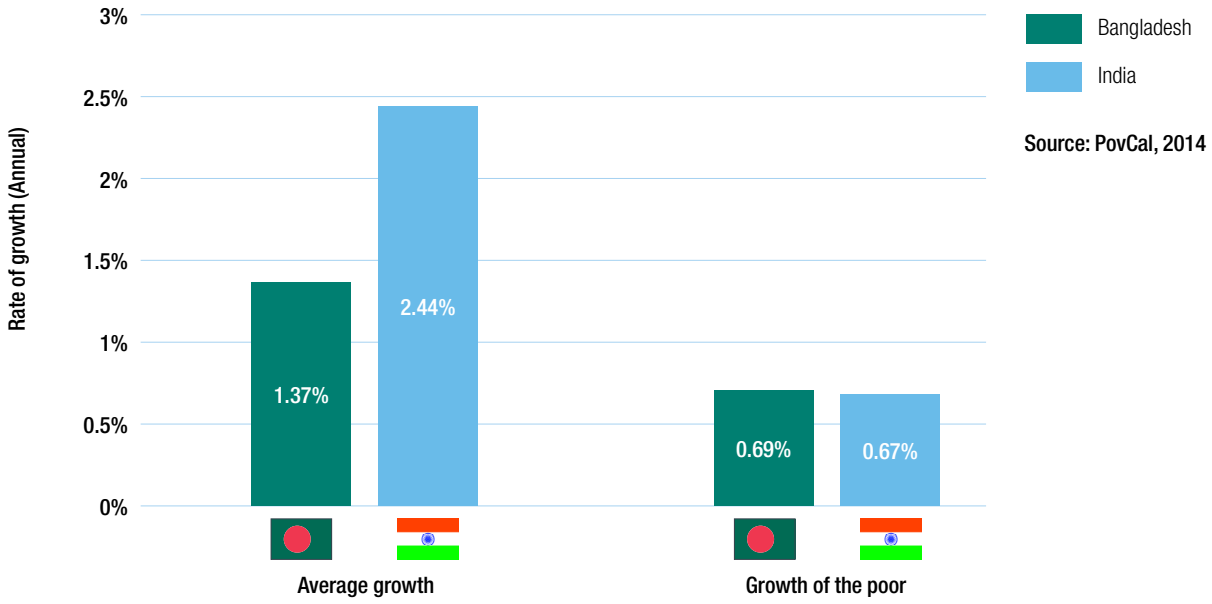
a. Redistribution of wealth: the role and limit of direct cash transfers

Extreme poverty could be eliminated tomorrow with little to no effect on global emissions through pure cash redistribution—at least in theory and in the short-term. The perfectly targeted redistribution of existing wealth could increase the consumption of those in extreme poverty to above $1.25 a day, again, with little or no impact on global emissions. This is not a radical idea – the former Director of World Bank Research, Martin Ravallion, makes the same point (Ravallion, 2013). The wealth needed to close the extreme poverty gap decreased to less than 1/2000 of global GDP by 2011 (World Bank, 2014b; PovCal, 2014).

Yet pure redistribution of wealth in the form of transfer of cash or consumables is unlikely to be a sustainable pathway to the permanent eradication of extreme poverty. A cash transfer would only help to raise current consumption, while regular payments would be needed to ensure that future consumption remains above $1.25 a day. The actual cost required to adequately deliver cash transfers to those in extreme poverty is likely to be well in excess of the size of the poverty gap itself. Ongoing cash

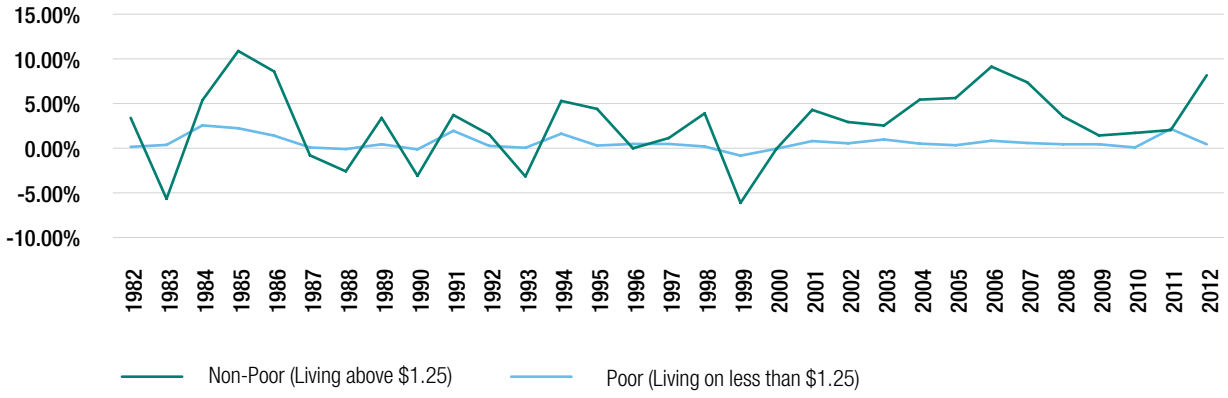
7 This is based on every publically available World Bank survey measuring extreme poverty in developing countries. Only data for every country where at least two household surveys have been conducted has been used, in order to chart a growth rate.

Figure 5: Comparison of growth rates in India and Bangladesh



Source: PovCal, 2014

Figure 6. Annual change in consumption of the poor and non-poor



transfers between countries that aim to benefit only those living in extreme poverty have no political precedent and are probably very unrealistic in the short term.

More importantly, most of the world's least-developed countries (LDCs) do not have enough domestic resources to rely on cash transfers to eradicate extreme poverty once and for all. Ravallion (2009) shows it is unreasonable to expect that even basic cash transfers are affordable until a country has an income per person in the order of $2,000-4,000 (2005 PPP). Most LDCs would therefore need far greater growth to raise enough domestic resources to rely on redistributing wealth to close the extreme poverty gap.

Ironically, countries with relatively low levels of extreme poverty can afford pure cash redistribution as a poverty alleviation mechanism, and this cannot, therefore, be seen as a substitute for growth altogether. Nevertheless, we should recognise that for middle-income countries with low relative levels of extreme poverty (including many Latin American countries, and increasingly China) (Ravallion, 2009), such cash transfers may still be essential in the 'last mile' of the journey from 'effective' zero extreme poverty toward truly zero extreme poverty. Cash (or consumption-based) redistribution is needed to permanently eliminate extreme poverty among some disadvantaged and marginalised groups in society, such as those who have disabilities or are older. This was one of the reasons for the introduction and continuation of social transfers in most high-income and some middle-income countries. It is also the reason that authors such as Greenhill et al (2015) advocate for global programmes to support the delivery of transfers and social guarantees for the poorest and most marginalised.

b. Broader forms of redistribution, or 'equalising policies', enable equitable growth

Direct cash transfers have their place in poverty reduction, but equalising policies that enable poor people to participate in the formal economy will allow them to contribute to and benefit from growth. While there remains great debate about how to reverse growing inequality, boosting labour productivity is seen as a fundamental part of ensuring more equitable growth (OECD, 2012). There seems to be consensus that this will involve a more comprehensive approach to 'redistribution', focused on the fundamental and structural conditions that affect poor people. In this sense, 'redistribution' simply means public interventions that reduce inequality—both by benefiting poor people directly and creating the circumstances in which they can benefit themselves as participants in the economy; this is why we have termed them equalising policies. This may include social programmes that directly supplement consumption of poor people, such as the globally-funded social protection, health and education guarantees advocated by Greenhill et al (2015) and a broader range of pro-poor policies. Such interventions also create many of the preconditions required to achieve zero net emissions. In this sense, action to eradicate poverty can be expected to reinforce our ability to deliver zero net emissions.

In Box 3, we illustrate what equalising policies need to achieve, using five elements seen as critical to more equitable growth. Many of these have broader public benefits that go well beyond the poorest people. However, their design must take into account the specific needs of the poorest people if they are to be redistributive. Infrastructure benefits poor people when it is planned to meet their needs; governance only benefits the poor if they themselves are enfranchised. Ultimately, however, the ability of growth to serve extremely poor people will depend not only on economic growth, or the public intervention to help poor people enabled by growth, but whether that public intervention is designed to help poor people themselves participate in that growth.

Box 3: Creating conditions for equitable economic growth

Without judging the relative importance of specific aspects of this shift, or the relative effectiveness of precise measures, we summarise five key elements seen as critical to more equitable growth, drawing on the work of the Chronic Poverty Advisory Network, which has built a substantial literature around what works to help people escape from poverty (CPAN, 2014). Development scholars may disagree on whether there are more or fewer elements to consider, but these five capture many of the tools we have at our disposal to enable the conditions for more equitable growth:

Boosting human capital

First, more equitable growth involves fundamental improvements in the 'human capital' of poor people. This encompasses better nutrition, reduced incidence of debilitating disease and increased levels of education, among other things (Mehrotra and Delamonica, 2007; Colclough, 2012; UNESCO, 2013). Education, for example, is seen as the single most important factor in stopping the transmission of poverty from parents to children and helping people to escape from poverty (O'Connell, 2013; Baulch, 2011). Across the world, evidence shows that the returns to education are positive and large across all educational levels (Montenegro and Patrinos, 2013). In other words, for every year of education, an individual is on average expected to earn higher wages. This trend is particularly strong in regions where participation in education is lowest, sub-Saharan Africa and South Asia (Montenegro and Patrinos, 2013). Education expands human capital productivity, meaning its broad availability will have an impact on the distribution of growth.

Asset accumulation

More equitable growth involves the accumulation of assets by poor people, which improves their income, and shields them from risks and instability (Alatas et al., 2013). Such assets encompass everything from land or livestock to buildings or machinery, providing a direct way to increase labour productivity, and, very often, access to more advanced production techniques. Asset ownership also creates a virtuous cycle of incentives (Meinzen-Dick, 2009). Wealth stored in the form of even basic assets (such as livestock, land and trees) has been shown to provide a buffer for future consumption against a range of shocks, such as those brought about by climate change (Scott, 2012). Without adequate assets, people who consume slightly above $1.25 a day could easily fall back into extreme poverty in the future (Pritchett et al., 2000). The access of poor people to finance is critical for such asset accumulation, and the accumulation of initial assets can lead to additional access to finance and, in turn, the accumulation of more assets, creating another virtuous circle (Kumar and Kumar, 2014).

Improving pro-poor infrastructure and services

More equitable growth entails public services and infrastructure designed specifically to service poor people, including energy, water and transport (World Bank, 2014a; Practical Action, 2014). People often stay in poverty because they are unable to exploit the returns to their own human capital and assets due to a lack of infrastructure and services relevant to their needs (Baulch, 2011). Without access to clean water, for example, the health of poor people is undermined (Schuster-Wallace et al., 2008). Without energy and transport, educational attainment is much more difficult. Similarly, public services and infrastructure increase the return of assets: agricultural produce will command a much higher price if it can be stored properly and shipped in a timely way to major markets (Jouanjean, 2013).

Increasing employment opportunities

More equitable growth also requires an economic structure that creates jobs: the single most important mechanism in lifting people out of extreme poverty (Baulch, 2011). A 2009 World Bank report that interviewed people from 15 countries in Africa, Asia and Latin America, indicated that it was finding jobs and starting new businesses that lifted those people out of poverty (Narayan et al., 2009). A critical level of economic diversity is needed to increase employment opportunities, including the development of a strong manufacturing and/or service sector (High-Level Panel of Eminent Persons on the Post-2015 Development Agenda, 2014; Vandemoortele et al., 2013). Of course, the expansion of employment requires education and other human-capital improvements that allow poor people to participate. Furthermore, migration can provide an opportunity for poor people to escape poverty, either directly by relocating for employment opportunities and/or indirectly through remittances from social networks (Baulch, 2011).

Enhancing governance and political representation

Finally, and perhaps most fundamentally, more equitable growth also encompasses changes to dimensions of life that may be affected by (and affect) all of the above, but are also unable to be equated to them: justice and the rule of law, political empowerment and freedom from the threat of violence, among others (IDLO, 2014). Many studies highlight the fact that people who are marginalised by governments, whether because of ethnicity, caste or race, are more likely to be in – and stay in – poverty (Baulch, 2011).

3. The impact of climate change on poverty

1. Pathways to a significant risk of catastrophic climate change

The effects of climate change are already clear. Average global temperatures today are estimated at about 0.85°C above pre-industrial levels, and concentrations of GHGs in the atmosphere are about 430 ppm CO2e (IPCC, 2014d).[8] The future physical geographic distribution of climate-change impacts and resultant economic impacts are, however, uncertain. Climate and natural-systems models can help to estimate these impacts, such as changes in climate as a result of varying emission levels, the incidence of climate extremes and disasters and the resulting damage;[9] meanwhile, macroeconomic and sector models can help estimate future economic impact. Together, these allow future impacts to be assessed through scenarios.

This paper uses two GHG emissions scenarios to illustrate how poverty and climate change intersect: BAU, whereby global average temperatures reach 3.5°C in 2100, and a 'zero net emissions' scenario, which indicates how fast we need to reduce emissions to stay within a 2°C increase in temperatures above pre-industrial levels (Table 1).

A 1.5°C to 2.5°C rise in global temperatures represents a potential 'tipping point', where the risks of irreversible events and global damages increase dramatically and 2°C is widely considered the cut-off point for 'dangerous anthropogenic interference' (UNFCCC, 2009) leading to irreversible and catastrophic climate events and global damages (IPCC, 2007). Even a 2°C scenario is considered only 'likely' (>66% probability) to avoid catastrophic risks. A very high risk of such catastrophic outcomes is experienced at 3.5° (IPCC, 2014f). There is, therefore, a very stark difference between the BAU and zero net emissions scenarios, with the first representing a significant risk of catastrophic climate change and the second representing a relatively safe bet.[10]

The BAU scenario involves only incremental changes within key sectors, while the zero net emissions scenario involves large structural changes across a number of sectors. For example, the zero emission scenario implies a peak in emissions at about 2030, and an almost 50%[11]

Table 1: Business-as-usual and zero net-emission scenarios based on the most widely-referenced sources for these scenarios of the IPCC and the IEA.

Scenario	Linkages with existing scenarios	Expected temperature increase versus pre-industrial levels (90% probability range shown within brackets)	
		2050	2100
Business as usual emissions	This corresponds to the IEA WEO 'Current Policies' scenario and its ETP '6 degree' scenario with 2100 GHG concentrations of 900 ppm in 2100. It is close to the middle of the IPCC range for baseline scenarios.*	2°C (1.4°-2.6°)	3.5° (2.5°-4.5°)
Zero net emissions	This corresponds to the IEA WEO '450 scenario' and its ETP '2 degree' and the IPCC RCP2.6 scenarios with GHG concentrations of 450ppm in 2100.	1.5° (0.9°-2.1°)	1.6° (1.0°-2.3°)

** Range from 720 to 1330 ppm CO_2e by 2100.*

8 The CO2-eq concentration in 2011 was estimated to be 430 ppm (uncertainty range 340 ppm – 520 ppm) in the IPCC fifth assessment report.

9 'Changes in the climate' refers to the direct impact of GHG emissions on atmospheric and ocean temperatures, atmospheric composition and ocean acidification, etc. The 'incidence of climate extremes and disasters' refers to the subsequent impact on the incidence of disasters including heat waves, droughts, floods, sea level rise, hurricanes, storm surges, coral reef extinction, ocean hypoxic zones and forest dieback. 'Damages' refers to impacts on human welfare, such as reduced agricultural production, poorer health or premature death, destruction of property, reduced enjoyment of environmental goods and services, human displacement and conflict.

10 This also justifies a focus on a zero net emissions scenario rather than some intermediate scenarios (e.g. 650 ppm). In short, although the risks certainly decline with intermediate scenarios, even those scenarios entail a significant risk of incurring the types of climate extremes and disasters (and associated damages) that we examine in our BAU scenario. If we want a high probability of avoiding those risks (especially in the context of poverty eradication), then a 450 ppm zero net emissions scenario represents the only option.

11 Here and elsewhere in this section, wherever we summarise evidence across a number of similar scenarios or studies, we use numbers rounded to the nearest 5%. This is to avoid giving a false impression of precision in these rough estimates.

decrease against current emissions by 2050. The two scenarios imply different policy actions, which drive distinct patterns of economic activity. These crucial differences have consequences for the eradication of poverty as they influence costs, benefits, and their distribution; this is examined at length in Section 4.

2. Avoiding catastrophic climate change: essential for the eradication of poverty

a. Climate change creates a significant threat to poverty eradication, even beyond 2030

To understand how climate change will influence poverty eradication goals, we look at climate impacts under a BAU scenario. The analysis focuses on the two decades following 2030, the window in which humanity hopes to achieve eradication of extreme poverty once and for all. Climate impacts will certainly affect the goal of poverty eradication up to 2030 as well, but data limitations make it difficult to assess the scale of this impact. Moreover, the nature of climate change is such that the impact from today's emissions will only be fully felt about ten years from now (Ricke and Caldeira, 2014). This means that historic GHG emissions have already made some climate impacts inevitable, even if there is significant uncertainty about exactly how much, meaning choices in the coming decade are more relevant two decades from now and beyond.

A number of climate impacts likely to occur between 2030 and 2050 are of direct relevance to poor people (IPCC, 2014e). Climate impacts from 2030 create a strong and costly headwind that pushes against efforts to eradicate poverty. There are a number of plausible mechanisms by which known environmental effects of climate change could hit the poorest people. These include:

- reduced primary sector productivity
- higher food prices
- higher rates of malnutrition
- damage from climate extremes (such as droughts, floods and storms)
- higher incidence of airborne diseases
- secondary impacts on child and female education, fertility and violent conflict.

Poor people tend to be more exposed to climate-impacted sectors. They are also predisposed to be more 'vulnerable' to climate change, in that they face more severe impacts and are less able to respond, adapt or recover (Barr et al., 2010). This is obviously true of the extreme poor, but even those just above the extreme poverty line remain vulnerable to climate change impacts. Importantly, poor people are unlikely to exhibit significant inherent resilience without income levels significantly in excess of $1.25 per day: where inherent resilience is broadly defined as the ability to avoid significant deterioration in one's livelihood or to restore one's livelihood quickly enough to avoid falling back into extreme poverty for an extended period of time.

Even at $2 per day, high levels of vulnerability remain. This represents an income level 60% higher than the extreme poverty line, but vulnerability persists from factors like a lack of household assets, credit, insurance, a social safety net and an adaptable skills set. A $2 per day line may be a very conservative proxy for a resilience line, but we use it in this paper to demonstrate how large populations of poor people may still be at risk of falling into extreme poverty, owing to climate change. Applying this threshold for vulnerability means that climate change threatens not only those currently living in poverty, one billion living on less than $1.25 a day, and two billion on less than $2, but also the roughly one billion people still projected to be below $2 by 2030 (according to the optimistic growth scenarios holding inequality constant). As a result, even climate damages not fully manifest until 2030 could pose a serious threat to achieving zero poverty goals.

b. The scale of potential climate impacts could be large enough to reverse most of the gains in poverty eradication achieved by 2030

To illustrate the potential impact on poverty, we will assess four impact pathways that comprise some of the larger and more robustly quantifiable estimated climate damages. While not a comprehensive assessment, available studies suggest that these capture the largest portion of direct climate impacts in the 2030-2050 period (World Bank, 2013). For each of these, an order of magnitude is estimated for the number of poor people exposed to climate damages, with the size of those damages relative to the expected gains in their livelihoods. This gives us a sense of the threat posed by climate change to the maintenance of zero extreme poverty from 2030 onward.

This approach is likely to underestimate the impact of the climate crisis on poverty goals, since it assumes climate change does not slow poverty eradication up to 2030. In reality, the impacts we discuss will gradually increase from now through 2050, involving a complex interaction with progress in the eradication of poverty. As such, the estimates here are a stylised average. They indicate the potential impact of climate damages at a point when they will have become measurably more significant, but also when the poverty problem should have become less significant. At the same time, as we can see from Table 1 above, even strong mitigation action would not eliminate all of these impacts. Nevertheless, strong mitigation efforts can be expected to significantly reduce the risk of such impacts, especially in the context of potential tipping points, and it becomes critical to avoid them worsening.

Impact Pathway 1 – More frequent droughts

The impacts on poverty of climate extremes—such as tropical storms, floods, droughts and heatwaves—are fundamentally different from that of gradual atmospheric warming. Historical extreme weather events have had ruinous and long-lasting impacts on the economic wellbeing of rural and urban poor (Shepherd, et al., 2013; World Bank, 2013b), leading in some cases to significant fatalities and dependence of large populations on aid for survival. At the aggregate level, a recent study found that a 1% increase in an area experiencing drought or flooding correlated to a 2.7% and 1.8% decrease respectively in the country's rate of GDP growth in that year (Brown et al., 2013). Climate extremes can, among other impacts, reduce crop yields by 45-80% and increase prices by up to 200% in a single season (Huho, et al., 2010). The poorest are disproportionately affected because they lack the means to adapt and rely more heavily on rainfall for agriculture (discussed further in the next section), health, and sanitation (World Bank Group, 2008). Therefore, even households showing relatively strong improvements in income and wellbeing over many years might see themselves pulled back into poverty by a single extreme event.

Droughts and their damages have already affected hundreds of millions of poor people in rural areas over the past three decades. From 1980 to 2013, large-scale droughts affecting millions of people occurred roughly every year or two, with mega-droughts affecting tens of millions occurring every three to four years in each major region (CRED, 2014). Studies also suggest there are likely to be large increases in the incidence of drought owing to climate change (Dai, 2010; 2013). The pattern and frequency of such climate extremes are difficult to predict. We make a plausible assumption that the frequency of droughts might double between 2013 and 2030, as we approach a 2°C rise in global temperatures under BAU. [12] We also assume the rural poor are affected proportionally to the rural population as a whole. Such events could pull an additional 200-300 million of extremely or moderately poor people in rural areas back into deeper poverty between 2030 and 2050.[13] If the impacts of floods, heatwaves, storms and other climate extremes are also considered, this estimate of the effect of climate extremes on rural poverty could increase significantly. [14]

Impact Pathway 2 – Reduced rural household income owing to declines in primary sector productivity

Across sub-Saharan Africa, South Asia, Southeast Asia and China, roughly 2.7 billion people depend on primary sectors (agriculture, livestock and fisheries) as their main source of income today. The proportion of rural households in poverty varies from about 10% in China to over 50% in much of Africa [15], with a total of about 700 million rural people in extreme poverty and relying on primary resources for their livelihood. There are roughly double the numbers of such people in 'moderate poverty', living on less than $2 a day. [16] This latter number will only decrease, to approximately 800 million by 2030, under optimistic growth conditions.

The rural poor face a series of challenges that threaten to reduce their expected income growth and delay their exit from poverty. The characteristics of these poor populations vary due to factors such as exposure to risk, dependency on primary sector incomes, current land productivity and access to productivity-enhancing techniques. Climate change could cause declines in agricultural, livestock and fishery yields, combined with general water stress and the potential 'collapse of the commons' (such as in groundwater levels and fish stock), with major impacts on their wellbeing. We focus here on the more gradual impacts affecting the agriculture and livestock sectors, which the greatest numbers of the extreme rural poor depend on for their livelihoods, rather than extreme events like the drought described in pathway 1.

From 1.5°C to 2°C of average warming is expected to reduce crop and livestock yields by an estimated median loss of 10-15% for regions with relatively higher exposure. [17] Thus, even those populations experiencing strong growth in agricultural productivity of around

12 Based on evidence in IPCC: Climate Change 2007: Working Group II: Impacts, Adaptation and Vulnerability: 3.4.3 Floods and droughts. Note that studies also point to an increased failure rate of the primary growing season (owing mostly to drought) from one in five years today, to one in four years, and then one in three years for warming of 1.5°C to 2°C for rain-fed systems across large portions of Africa (Jones and Thornton, 2009).

13 Strictly speaking, some of the same people could experience multiple disasters over the course of two decades, so these numbers may not represent distinct individuals.

14 Estimates of historic damages for floods are quite similar to those for droughts, although more frequent in Asia than Africa. Heatwaves are not as well tracked, but massive heatwaves have been identified several times in the past three decades, affecting a million or more people, and these are expected to increase considerably in the future.

15 Figures are averages of rural poverty rates taken from the World Bank's 'World Data Bank' (2015).

16 According to the World Bank's 'World Data Bank' (2015), poverty rates (according to national poverty lines) are about 12-30% in Southeast Asia, 20-35% in South Asia, and 35-70% in Sub-Saharan Africa in 2011.

17 These are median impacts, as estimated in Roudier et al. (2011) and Knox et al. (2012), for crop yield estimates by region; and Butt et al. (2005) for livestock production estimates. All studies looking at global warming scenarios roughly in the 1.5° to 2.0° range were considered. These estimates generally do not take the potential effect of adaptation measures into account.

1-2% yield growth per year could experience a decade-long set-back in both their income growth and exit from poverty. [18] Those facing more severe circumstances fare worse. If the same level of warming were to cause larger impacts, 20-30% yield reductions and poorer and more vulnerable regions slowing to 0.5-1.0% productivity growth per year, it could set back their income growth for decades. [19] Moreover, even if agricultural households have non-farm income sources to which they could turn, the underlying drag on the rural economy could also impact non-farm income.

To gauge the scale of these impacts, we will focus on the two regions with the largest numbers of rural poor: Sub-Saharan Africa and South Asia. There is significant evidence of the negative impacts of a 1.5°C to 2°C warming scenario by 2030-2050 for both regions. Although estimates vary, as noted in Section 3.1, both regions are likely to have large numbers of both extreme and 'moderate' rural poor (less than $2 a day) in 2030. Using the recent World Bank assessment (World Bank and International Monetary Fund, 2014), we estimate that both regions combined will have roughly 660 million extreme and moderately poor rural households reliant on agriculture as a main source of income. [20]

For those rural poor who sell excess produce on the market, the impact of reduced yields could be somewhat ameliorated through higher prices. However, this heavily depends on the amount of excess they are left with after crop losses and rural economic decline. Since there is a possibility of some gain for such households, we have simplified the assessment by focusing mainly on subsistence farming households. These make up about three quarters of the rural poor in Sub-Saharan Africa and 30% in South Asia (AGRA, 2013). This means that roughly 400 million of extreme and moderate poor (out of the 660 million mentioned above) will be highly vulnerable to the potential setbacks from climate change induced by reductions in yields.

The proportion of this vulnerable group actually exposed to these impacts is subject to some uncertainty, as there are too few studies looking at multiple crops across multiple regions. Based on the limited available evidence, we believe exposure rates of 30-60% for a 1.5°C to 2°C warming scenario are reasonable. [21] Applying these exposure rates to the above estimate of the vulnerable population would mean that 120-240 million people still in extreme or moderate poverty in 2030 will be suffer continued setbacks to their efforts to escape from poverty for years, and possibly decades. Agricultural productivity does of course have broader determinants than just droughts, but we conservatively assume for calculation of cumulative totals that all poor people impacted by losses in agricultural productivity also faced drought.

Impact Pathway 3 - Increased food prices as a result of declines in primary sector productivity

A third impact pathway is the indirect effect of rising food prices. This is an impact of declining primary sector productivity and reduced food supply on both rural and urban net food buying groups (buying more food than they sell) (Porter et al., 2014). Reduced yield of staple crops is estimated to increase prices by 10-60%, with an average of 30% in 2030, in a low productivity scenario (Hertel et al. 2010; Porter et al., 2014). Those living in extreme poverty in Sub-Saharan Africa and South Asia spend approximately 35% and 30% of their budget on food, respectively. A 30% increase in food prices would therefore reduce the purchasing power of these individuals by10% (Ahmed, Hill, Smith and Wiesmann, 2007). Even assuming relatively strong annual income growth of 1-2% [22] among the extreme and moderate poor, this would mean a setback of up to a decade in the income of net food buying groups.

The urban poor are the most vulnerable, although all poor net food buyers and non-agricultural households are expected to be affected significantly by rising food

18 With underlying productivity growth of 1%, a 10-15% productivity loss would take 10-14 years to recoup. At 2% underlying growth, this would take 5-7 years.

19 Even using a fairly optimistic productivity growth number of 1% (which is well above what many of the poorest regions have experienced in recent years), it would take about 18 years to overcome a productivity shock of 20%.

20 We have combined World Bank estimates with projections for the number of people living on less than $1.25 per day, combined with income growth projections to estimate the number living on between $1.25 and $2 per day to estimate that roughly 500 million people (rural and urban) will be living in extreme poverty, and another 500 million in moderate poverty in 2030. We then use estimates that about two thirds of the total poor in these regions rely on agriculture as their main source of income to arrive at the estimate of roughly 660 million.

21 For this estimate, we have used data from World Bank's (2013) Turn Down the Heat, showing the likely exposures to unusual or unprecedented heat events as a proxy for the extent of exposure more generally.

22 World Bank estimates place increase in income of extreme poor at 0.6% per year between 1981 and 2010, rising to 0.9% when SSA is excluded.

23 This figure is an average of the net buyers, as calculated from a study in the following countries: Ethiopia, Zambia, Madagascar and Bangladesh. This may not accurately reflect the actual average across all countries making up SSA and SA (Aksoy and Hoekman,, 2010).

prices (World Bank Group, 2013; Hertel et al., 2010). Net food buyers overall make up approximately 70% [23] of the poor population in Sub-Saharan Africa and South Asia, which could correspond to about 700 million people vulnerable to this risk by 2030. [24] About 350 million of these will be urban households, all of whom will be vulnerable to food price increases. [25] The other 350 million will be rural households, which are sometimes both producers of food and net buyers of it. In this sense, the price impact could compound the negative productivity effects felt by some rural households, as discussed above. For example, subsistence households that engage in non-agricultural activity to supplement their income to purchase food would find themselves doubly affected.

Again, it is difficult to assess what proportion of this vulnerable population will actually be exposed to food price increases. There is likely to be significant geographic overlap between the areas affected by price increases and those affected directly by a loss in agricultural yields. This is because local productivity fluctuations have their largest impact on local food prices, especially in areas with extreme poverty (FAO et al., 2011). Again, if we assume exposure rates of roughly 30-60%, there will be 210-420 million people still in extreme or moderate poverty in 2030, who will suffer continued setbacks to their efforts to escape from poverty for a decade or more.

Some rural populations affected by declines in agricultural productivity may also be net buyers of food, and thus affected by both pathways, but the combined impact of these two pathways points to a strong and hard-to-avoid drag on the eradication of poverty affecting approximately half a billion people. The combined affect is particularly important since it means that even those rural households attempting to adapt by engaging in non-agricultural economic activity, migrating to urban areas for work or engaging in a combination of activities will find it hard to avoid at least one, if not both, these impacts.

Impact Pathway 4 -Increased child malnutrition and stunting as a result of declines in primary sector productivity

Another impact pathway related to declines in crop productivity and a rise in food prices is the increased incidence of malnutrition and stunting, which are one of the most serious underlying drivers of both prolonged and intergenerational poverty. For adults, a variety of studies have shown that inadequate calorie and nutritional intake can seriously reduce labour productivity. Although we do not quantify this significant compounding effect, it would even further hinder the exit from poverty for those rural and urban poor exposed to losses in crop yields and higher food prices. [26]

In addition, when suffered in childhood, malnutrition and stunting can have long-term effects on adult success, including lower education achievement, lower economic status in adulthood and increased likelihood of death (Victora et al., 2008; Black et al., 2008). This in turn can have an impact on their own personal income and a cumulative impact on their countries' levels of poverty and economic growth. Although the extent of this impact varies, studies have shown that childhood malnutrition and stunting can lead to large decreases in time worked, and in the productivity of that work, with some estimates indicating a 12-20% loss in annual earnings (Banerjee and Dulfo, 2011; World Bank, 2006). In the context of average annual income growth of 1-2% among the extreme and moderate poor, this would mean a setback of roughly one or two decades.

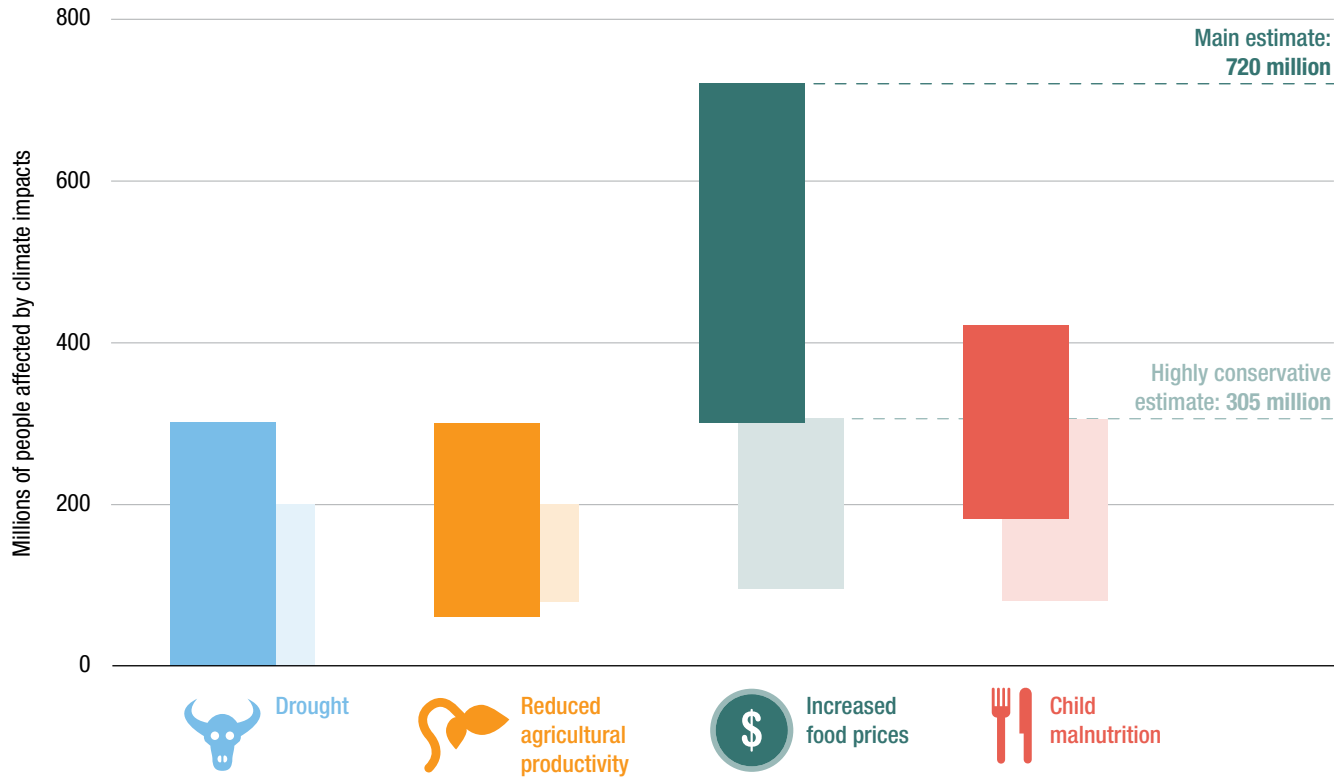
A recent study indicates that 1.2-1.9°C warming will increase malnourishment and stunting by around 100% and 20-40%, respectively, as compared to a scenario with no further climate change (Lloyd et al., 2011). Such an increase means that roughly 15-24% of children will be malnourished and 5-8% of children will be stunted (in South Asia and Africa respectively) who wouldn't be otherwise. This translates into around 240 million additional malnourished children and 60-80 million facing stunted development between 2030 and 2050 in sub-Saharan Africa and South Asia. As a result, these children will experience a setback to their progress out of poverty by one or two decades. Whilst literature suggests that up to 60% of stunting could be attributed to other environmental conditions (predominantly lack of water and sanitation) (Lloyd et al., 2011), we have

24 How individual households are affected depends on a number of factors, including: whether they are net sellers or buyers of the commodity whose price is increasing, the possibility of substituting out of that commodity and ability to increase production. Due to the high level of specificity, we have to make some broad assumptions about impacts when estimating the number of people affected. However, in general effects on both rural and urban poor, the impact will be negative (Ivanic, Martin, & Zaman, 2012).

25 Projecting urbanisation trends from the last decade, we estimate that in 2030, the urban poor alone will number about 180 million under $1.25 per day and about 170 million more under $2 per day across South Asia and Sub-Saharan Africa.

26 Quantifying this impact is difficult, since it depends to some extent on crossing specific thresholds. For example, the severely malnourished, or the relatively well-nourished may not see much deterioration from small changes in calorific or nutritional intake, while those in the middle might see quite large productivity impacts. That said, studies do point to very large impacts, with increases in productivity from better nutrition having an even greater effect than increases in critical non-labour inputs such as fertilisers. See Banerjee and Duflo (2011), Lloyd, et al. (2011), World Bank (2006) and Ayalew (2003).

Figure A: Up to 720 million people are at risk of facing extreme poverty from climate impacts between 2030 and 2050



Authors' calculations based on data from multiple sources (see section 3.2.b for citations and method)
Opaque bars show main estimates; transparent bars show highly conservative estimates.

taken a conservative approach in our estimates and assumed that all stunting is a result of malnutrition. Because stunting and malnutrition will occur as food becomes more expensive (pathway 3) or harder to produce (pathway 2), we again conservatively exclude these from our cumulative estimates of total impacts.

We estimate that up to 720 million people are at risk of facing extreme poverty from climate impacts between 2030-2050, based only upon the best-understood and most easily quantified impacts (see Figure 7 and Table 2). This is about the same number of people as were lifted from extreme poverty in the last two decades of record development progress (Povcal, 2015). Many of these people will also be hit by multiple impacts, sometimes all four, making their poverty even more intractable.

And while these four impact pathways focus primarily on the rural poor, the urban poor will also be adversely affected by climate change. This will become increasingly important for poverty eradication as the proportion of poor living in cities is increasing (Ravallion et al., 2007). Storms, floods and heatwaves are all climate extremes that have a direct impact on the wellbeing of the urban poor. Indirect impacts on health and education, for example, could also be significant. Studies have not yet provided a comprehensive picture from which the adverse impact on a zero extreme poverty goal can be estimated, but it is easy to understand how the impacts of climate change in a realistic scenario have huge effects on eradicating extreme poverty and sustaining that achievement.

c. Climate change beyond 2°C threatens unavoidable impacts on the poor

Risks of major climate impacts begin as we approach between a 1.5°C and 2°C global mean temperature rise. Even if we steer the global economy toward zero net emissions before the century's end, many of the impacts outlined in the prior section may occur and place a considerable drag on our efforts to eradicate poverty. If we fail to do this, we will surpass 2°C and achieving the zero poverty goal pulls out of reach. Approach 3.5°C and the eradication of extreme poverty may be almost impossible, even if the world is likely to be significantly wealthier by the second half of this century. Broad assessments of the potential catastrophic impacts at these levels of climate change include, among other effects:

- a 40% decrease in precipitation in southern Africa, where crops and livestock remain largely rain-fed
- a rise of 100 cm in sea-levels by the 2090s, with 15% of Guinea-Bissau and Mozambique's population at risk of flooding by 2100
- an increase of up to one third in the frequency and wind-speed of the most intense storms and cyclone-

Table 2: Estimates of additional numbers of poor people impacted between 2030 and 2050 by even a 2° C mean temperature change, as a result of its most quantifiable impacts: declining primary sector productivity, climate extremes and child malnutrition and stunting

Impact pathway	Description	Assumptions	Additional number of poor people as a result of climate change
Decline in primary-sector productivity (direct impact)	Estimated impacts of declines in agricultural and livestock productivity are applied to the likely size and distribution of the rural poor in 2030 (living on up to $2 per day) in sub-Saharan Africa and South Asia.	Assumes that productivity declines of 10-15% on average (and up to 20-30% in more extreme cases), affecting between 30-60% of the poor population. Only about half of poor rural households are defined as vulnerable, owing to their reliance on subsistence agriculture.	120-240 million people in extreme poverty or 'moderate' poverty (living on less than $2 per day) exposed to multi-year, possibly decadal, setbacks to their efforts to exit extreme poverty.
Increase in food prices (indirect impact from declining primary-sector productivity)	The impact of price increases on disposable income of the poor is estimated by applying the price increase of staple crops to the proportion of income spent on food by the urban and rural poor.	Assumes that the price of staple crops increases by 30% on average; that roughly 70% of poor households are net food buyers; and that between 30-60% of those will be exposed to the price increase. Roughly half of those will be rural households, some of which may also be impacted by Pathway 1	210-420 million people in extreme poverty or moderate poverty will suffer a decade or longer setback to their efforts to exit extreme poverty. Roughly half of those will be rural households.
Child malnutrition and stunting	Estimated impact of climate change on the number of additional children suffering from malnourishment and stunting as a result of climate change over the course of each decade in sub-Saharan Africa and South Asia as global temperatures warm to 2.0°.	Assumes 15-24% of children will be malnourished and 4-8% of children will be stunted who wouldn't otherwise be so, in a 2.0° rise.	About 240 million children are malnourished, with while 60-80 million of these suffering stunting between 2030 and 2050, primarily via impacts from pathways 1 and 2.
Climate extremes	Estimated impact of droughts on the livelihood of poor rural households by combining historic damage data, projections of future droughts, and the likely size and distribution of the rural poor in 2030, across regions.	Assumes that the frequency of such events might double in the period of 2030 to 2050 (vs. 1980 to 2013) as we approach 2.0°. Does not consider impacts of floods or other extremes. This will be one of the drivers of impact pathways 1, 2 and 3, although not the only one. Climate extremes will have broader impacts: rapid reduction in agricultural productivity, reduction in availability and quality of rural water and sanitation, and displacement of populations, among other impacts.	An additional 200-300 million of the extreme or moderate poor in rural areas pulled deeper into poverty each decade through exposure to extreme drought.

related rainfall in South East Asia and the Philippines, with higher levels of flood risk in low lying and coastal regions (World Bank, 2013d).

While these impacts would occur around 2050, when there should be far fewer extremely poor people, the scale of these impacts may also mean much greater wealth is needed to remain resilient to them. (As discussed, this paper uses the conservative $2 a day as a proxy for a 'resilience' line.) Predictions beyond 2050 are bound to be very speculative, but it is plausible that these more extreme climate damages could pull hundreds of millions of people back into extreme poverty even in the second half of the century, essentially reversing many of the gains achieved in the first half. Furthermore, the plausible effects of climate change on poor people that have been outlined by our three impact pathways take the continued historical trends in growth as a given. This may be overly optimistic (see Section 2), so even with strong baseline trends, sustained poverty eradication beyond 2030 is not likely to be possible under the BAU scenario without significant additional efforts. We consider the scope for climate change adaptation and mitigation measures in turn below.

d. Adaptation offers a costly and only partial solution

Investments in adaptation can reduce the future impacts of climate change on poverty eradication. In many cases, some adaptation measures are justified even at today's level of climate change, as not all countries are well adapted to even their existing climate (Burton, 2004). While an analysis of the potential adaptation actions that can defend poverty targets is beyond the scope of this paper, it is clear that adaptation is costly, even under conservative warming scenarios (see Figure 8). It also cannot completely safeguard against the impacts of climate change, even with impacts at low levels.

In 2007, the UNFCCC estimated that by 2030, adaptation would require between $28-67 billion per year of investment and financial flows in developing countries in five key sectors (UNFCCC Secretariat, 2007).[27] Earlier World Bank estimates placed the cost at $10-40 billion (World Bank Development Committee, 2006), regarding this as a 'climate mark-up' on climate-sensitive investment. More recent World Bank analysis, assuming adaptation that avoided 'all' human welfare loss from climate impacts, has placed the annual costs in developing countries at over $100 billion by 2050 in a 2°C world (World Bank, 2010).[28] These costs increase dramatically as temperatures increase. An evaluation of the adaptation gap in Africa has found that present and committed climate change will cost $7-15 billion a year by 2020 (Schaeffer et al., 2013). In a below 2°C scenario, costs could reach $35 billion by 2050 and $200 billion by 2070; if temperatures exceed 2°C by a large margin, catastrophic impacts (like major sea-level rise) begin to result in much larger damages of up to $350 billion a year.[29]

The efficacy of adaptation measures is largely untested against a world of 3.5°C or more and its expected climate extremes. Even at levels of warming of 1.5°C to 2°C, measures are unlikely to eliminate all negative impacts. Residual damages occur because of technical constraints or prohibitively expensive adaptation measures that make

Danilo Pinzon/ World Bank Photo Collection - Flickr: Worker at waster water treatment facility. Manila, Philippines

27 The UNFCCC included five sectors: agriculture, forestry and fisheries; water supply; human health; coastal zones; and infrastructure. IPCC SRES A1B and B1 scenarios were used for water and coastal zones; variations from IPCC IS92a (stabilisation at 750 ppm by 2210 and one at 550 ppm by 2170) for human health; and the IEA WEO reference scenario for agriculture, forestry and fisheries. The operating and maintenance costs of adaptation measures were excluded, as were adaptation measures required in mining and manufacturing, energy, retail, tourism and ecosystems. Global costs were estimated at $49-171 billion per annum.

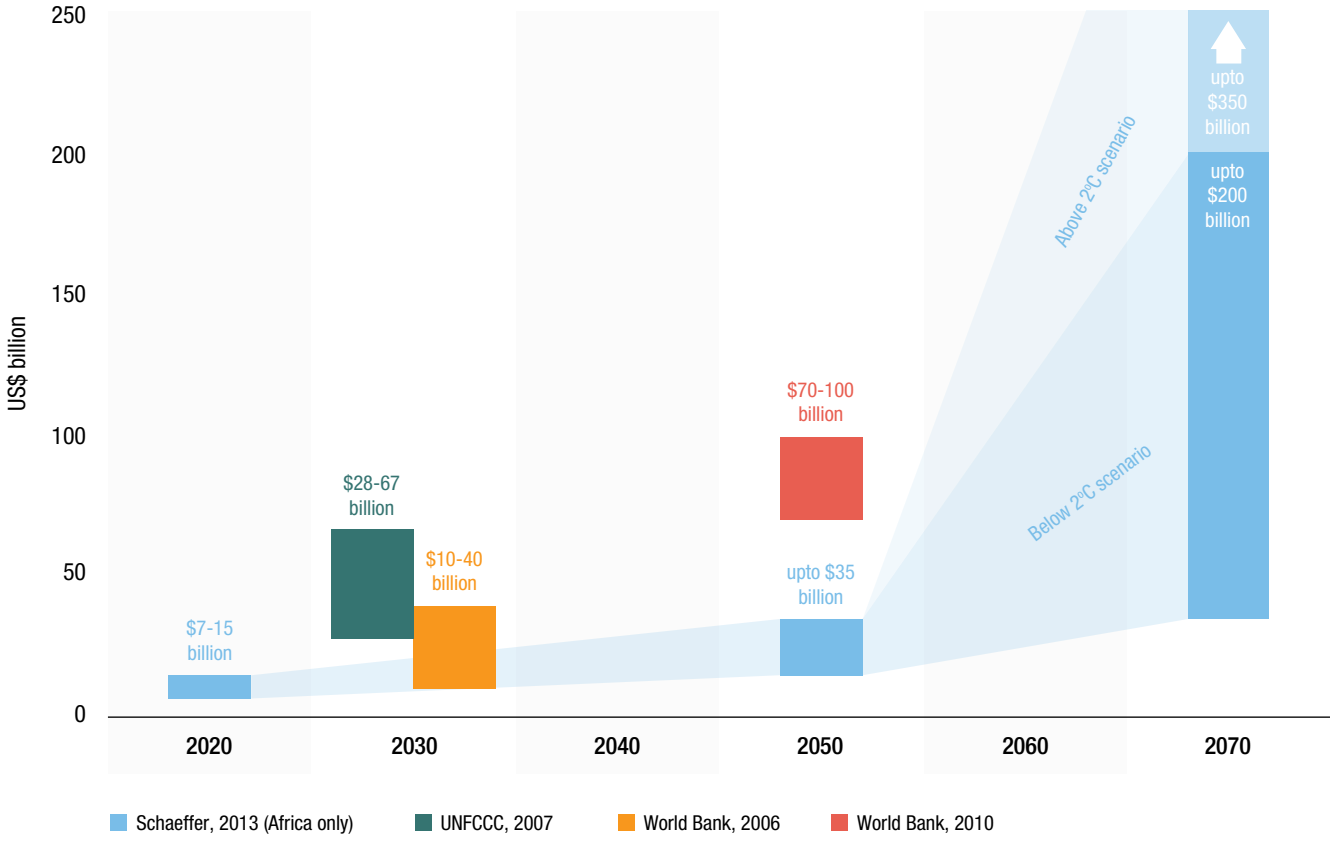
28 The World Bank report, *Economics of Adaptation to Climate Change*, (2010) used more precise unit costs and included those for maintenance, as well as risks from sea-level rise and storm surges. Scenarios were based on the following models: A2 SRES emissions, a 'relatively dry' scenario from the CCSM3 climate model of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and 'relatively wet' scenario from the Mk3.0 climate model of the National Centre for Atmospheric Research (NCAR).

29 These cost estimates are likely to be conservative due to the uncertainty and diversity of climate impacts, the multitude of possible adaptation options, data limitations in a number of sectors and the fact they omit 'softer' adaptation measures, such as behavioural and policy measures, focusing instead on 'hard' adaptation measures that are easier to cost (OECD, 2008; Parry et al. 2009; IPCC, 2014f).

such damages unavoidable (Parry et al., 2009). They require long-term structural adjustment, such as migration away from inundated coastal areas. Estimates of the extent of residual damages vary greatly and are inherently uncertain. Studies have estimated that they account for anywhere from 20% to 50% of total climate damages (UNFCCC, 2007; Deryng et al., 2011).[30] These could well be felt by poor people, especially where the damages have an impact on livelihood strategies from which poor people cannot diversify, where robust insurance markets may not be available or where disaster relief is more difficult to deliver. For example, land may become unproductive if moisture levels decline past the point where cultivation is viable (Stabinsky et al., 2012). In such a scenario, the rural poor may see both their source of income and primary assets deteriorate and have few available employment alternatives. Insurance against such an event may not be available and disaster relief may be either incomplete or temporary. This can be particularly damaging where core development and poverty measures, such as education or labour-market support, are not available to offset these negative impacts in the long-term.

The above represent the best available estimates of adaptation costs in 2030. Even if uncertain and incomplete, they provide an indicative picture of the likely costs of climate change to anti-poverty efforts. Countries with high levels of extreme poverty would face tens of billions of dollars a year in adaptation costs by 2030, equal to anywhere from 0.2% to over 1.0% of GDP in that year compared to projections with no such impacts (IMF, 2013). Poorer regions like Sub-Saharan Africa are likely to experience even greater costs. Such investments are bound to crowd-out other productive investment opportunities, including those made to achieve zero extreme poverty. Adaptation costs are, by definition, additional costs that provide no inherent co-benefits. At the same time, the countries affected would still be left with significant levels of residual damages, which could reinforce or engender extreme poverty among tens or even hundreds of millions of people. This will inevitably put a further burden on their core poverty eradication efforts and increase the demands on limited institutional capacity and technical skills.

Figure 8: Estimates show growing annual adaptation costs in developing countries



30 In 2007, for example, the UNFCCC estimated that 80% of the costs of potential impacts might be avoided; Deryng et al. (2011) estimated that only 20-65% of losses could be avoided.

4. Achieving zero extreme poverty on the path to zero net emissions

1. A zero net-emissions pathway is feasible and affordable

There are multiple scenarios for the achievement of zero net emissions before the century's end ('zero-emissions pathways'). Most widely accepted scenarios exhibiting fairly similar characteristics, summarised in Box 4 below. The scenarios forming the basis of this analysis are the most widely built-upon scenarios for more detailed efforts to assess the costs and benefits of climate action. They provide an initial assessment of the trade-offs of a pathway towards zero net emissions. Different scenarios for the achievement of zero net emissions present a range of benefits and costs related to how it is achieved. This depends largely on assumptions about economic growth, consumer and company behaviour, and the availability and cost of key technologies. The cost-benefit estimates also depend on how thoroughly the methodology incorporates market imperfections and the full set of potential economic impacts. Leading assessments are now incorporating transformational, as well as incremental, shifts in major economic systems, along with a more explicit role for innovation. They also incorporate co-benefits, such as reduced price distortions (e.g. from fossil-fuel subsidies), reduced local pollution (with improved health) and improved ecosystem services (e.g. water filtration). The resulting zero emissions pathways highlight the importance of specific structural shifts in achieving an efficient zero-carbon transition. This is especially true for urban development, agriculture and land-use and in energy, with underlying support from financial and innovation systems.[31]

About 50% to 90% of the actions required by 2035 for a zero net emissions pathway are 'negative cost' according to recent estimates (NCE, 2014; IPCC, 2014c).[32] Generally, the impacts, both positive and negative are modest. This means many, if not most, actions required for GHG mitigation by 2030 provide more quantifiable economic benefits than costs.

This underscores, first and foremost, the potential for high-income and upper middle-income countries and regions to move to a zero net emissions pathway without harming (and potentially benefiting) their growth trajectory. Since higher income populations are responsible for the large majority of emissions, action on their part is critical to avert the impact of climate change on the extreme poor. In light of the negative impact and cost of BAU observed above in Section 3, a zero net emissions commitment by high and upper middle-income countries is a critical and reasonable contribution (both morally and economically) to ensuring the eradication of poverty. In light of this, and the poverty implications of failing to decarbonise, it would be policy incoherent for high-emitting economies to prioritise the eradication of extreme poverty (either globally or domestically), while failing to reign in emissions in line with a zero net emission trajectory.

The reality is that a zero net emissions goal also has development implications outside the wealthiest countries, including those with high levels of extreme poverty. Unfortunately, there are relatively few specific assessments of zero-emissions pathways for countries with the highest levels of extreme poverty. None of these comprehensively look at the implications of climate action by poor countries on their ability to eradicate poverty. However, by looking at assessments for key regions with large amounts of extreme poverty, along with aggregating existing information from more specific studies, we come to some initial conclusions about the possible synergies between achieving zero net emissions and achieving zero extreme poverty.

31 The transformation of these systems is necessarily covered only at a high level in this report (see Section 4.3). The authors recognise the need for, and continue to conduct, detailed research in each of these areas.

32 Note that reports do not always use the same timeframes. Detailed analyses of the mitigation 'levers' tend to focus on the 2030-2035 timeframe (when current technologies are most relevant).

Box 4. Key features of analysed zero emission scenarios

- **They aim to stabilise GHG concentrations at less than 450 ppm.** They are, therefore, meant to avoid some of the more damaging climate impacts discussed above.
- **They recognise that BAU development pathways are not necessarily the most efficient or optimal.** So they account for potential improvements to economic output generated by a shift away from BAU.
- **They prioritise the lowest cost mitigation actions for early uptake, including 'negative cost' ones.** Therefore, a large proportion of climate action by 2030 is expected to increase overall economic growth, as well as potentially reduce the cost of basic services like energy, water and transport.
- **They prioritise actions with a higher (positive) economic cost to the extent that they are necessary to avoid 'lock-in' (i.e. high adjustment costs later).** Therefore, the potential negative economic impacts of climate action come primarily at relatively high levels of emissions reductions.
- **They assume decision-makers have the foresight and capacity to make optimal choices.** Therefore, they don't account explicitly for potential institutional and political constraints.
- **They generally assume that capital is available (at a price), and that it can be re-allocated freely around the economy.** Therefore, they do not look at capital-market imperfections that might be quite common in poorer communities.

a. In countries with high levels of extreme poverty, many emissions reduction measures are growth enhancing

Zero-emissions pathways can be beneficial to growth in countries with high levels of extreme poverty, if the transition to these pathways proceeds efficiently, taking into account broad economic impacts. The growth benefits of a zero-emissions pathway for poorer countries are driven by two key factors: First, these countries have a large number of opportunities to reduce emissions at negative cost, which can boost growth. Second, these countries' emissions are expected to peak later and come down more gradually than those of more developed countries. Harnessing this growth potential, however, requires decision-makers not only to have the foresight, capacity and resources to make the right choices, but also the ability to act promptly, as delayed action will increase costs in the form of stranded assets and committed emissions (Fay et al.,, 2015, New Climate Economy, 2014).[33] Poor countries that act promptly should also receive international transfers to support this transition, as net positive cost mitigation opportunities in a developing country may be relatively cheap to a richer country and yield global benefits. However, the domestic benefit of these opportunities does not depend on uncertain commitments by richer countries.

Work to date points to a significant number of growth-enhancing mitigation opportunities in LDCs, although a relative dearth of studies makes it difficult to assess the mitigation potential and macroeconomic cost-benefits across these countries systematically and comprehensively. To obtain a preliminary assessment, we look at six major studies covering the two regions accounting for most of the extreme poor: sub-Saharan Africa and Asia. We also highlight some significant progress in the past few years regarding our understanding of mitigation options and their macroeconomic impacts (Figure 9).

A number of country-level marginal abatement cost curve (MACC) assessments identify improvements to high-carbon BAU pathways using available technologies: these MACC analyses generally show that at least the first 15-30% of emissions reductions from BAU are growth enhancing. They tend to find negative GDP impacts for activities reducing emission beyond these levels, though quantitative results vary due to the methodological limitations. These studies are limited, however, by focusing on a relatively restricted set of incremental improvement to current economic activities. They do not consider 'transformational' change, such as significant shifts in patterns of urban development or agricultural land use. Likewise, they do not assess a full pathway to net zero emissions or provide an estimate of the aggregate economic impact, positive or negative.

A few examples illustrate the results of these efforts. The Ethiopian government's Climate Resilient Green Economy (CRGE) Strategy found that emissions to 2030 could be reduced by 33% (vs. BAU)[34] at negative cost, creating significant opportunities across sectors, including agriculture and forestry (MoFED, 2011). The study also found these emissions could be reduced by a further 25% at less than €10 per tonne of carbon dioxide equivalent. In India, a McKinsey study of mitigation options found India's emissions to 2030 could be reduced by about 15% (vs. BAU) with actions involving a negative cost and by

33 Urgency of action to ensure net negative costs is a key message in the World Bank's 'Decarbonising Development' report (Fay et al., 2015)

34 Throughout the studies surveyed here, assumptions about BAU emissions growth vary to some extent. In particular, government-led studies often assume higher BAU growth rates. Assumptions were reviewed to assure broad comparability with our core scenario set, and the validity of our key conclusions.

further 10% at a cost of less than €10 per tonne. It found very few negative cost opportunities related to agriculture and forests, but also that very large emissions reductions in these sectors (even vis-á-vis current emissions) were possible at a cost of less than €20 per tonne (McKinsey and Co, 2009).[35]

A more sophisticated set of studies have used energy system and macro-economic models to more thoroughly understand the optimal sequencing of emissions reductions and their impact on aggregate growth. These studies also tend to assess a more comprehensive set of mitigation measures and, as a result, have identified a larger set of opportunities. An assessment generated by the IEA (and built upon by the OECD)—the 'Efficient World Scenario' (EWS)—found significant opportunity for negative-cost emissions reductions and a strongly positive impact on growth (OECD, 2014).[36]

Across China, India, Africa and Southeast Asia, these more sophisticated models show that emissions compared to BAU[37] to 2035 can be reduced by about one third through such growth-enhancing mitigation actions. These emissions reductions improve GDP by 3.9% for least-developed African countries, 2.4% in Indonesia, 2% in India, 1.6% for other ASEAN countries and 1.4% for China. This compares to a world average GDP increase of 0.9% (IEA, 2012). Importantly, the household consumption benefits appear to be about 40-70% greater than the overall GDP benefits. A World Bank study using a similar methodology in Nigeria examined a low-carbon scenario in which Nigeria's emissions to 2035 could be reduced by 50% (vs. BAU) (Cervigni et al., 2013). It found that 62% of the reductions (a 31% reduction vs. BAU) could be achieved at negative cost. It also found a net positive impact on GDP of about 1% through the full low-carbon growth pathway vs. the BAU scenario.

The number of growth-enhancing mitigation options expands when analyses take into account additional 'co-benefits'– that is improvements to human health and welfare not associated with avoiding climate change. The cumulative positive climate impact of these mitigation options also expands as the range of options increases. Recent studies have begun to assess the major climate action co-benefits, including reduced air pollution, improved ecosystem services and reduced traffic-related costs. A recent World Bank study looked at mitigation opportunities in energy efficiency and clean transport identified through previous marginal abatement cost curve studies and their local air pollution co-benefits. According to such analysis, emissions in India and China could be reduced by roughly 30% (vs. BAU) at negative cost (Akbar et al., 2014). This is comparable to the upper range of previous studies that disregarded local air pollution, even though this co-benefits study examined only two sectors. The study also found that taking into account additional co-benefits doubled the size of the positive economic impact, suggesting the extent of growth-enhancing mitigation measures could be much larger than found by previous studies.

The New Climate Economy Report concluded that up to 50%, and possibly up to 90% of the emissions reductions required by 2030 could be achieved at no cost to economic growth, when considering both co-benefits and a wider range of 'transformational' approaches. Compared to previous analysis, the report found that the number of negative cost opportunities could be almost 50% greater, once co-benefits were properly factored in, and that the net benefits of many opportunities were two to three times greater than previously estimated. Case studies in India, China and Ethiopia suggest these findings apply with equal strength to poorer countries. The report also lays out a set of transformational changes related to urban development and land-use in particular, that would allow these countries to leapfrog to more efficient models of development. Overall, this would suggest that emissions reductions of up to 40% (vs. BAU) could be achieved through growth-enhancing mitigation opportunities in these three countries, although a more thorough assessment would be required to confirm these numbers (NCE, 2014).

b. Growth enhancing opportunities can achieve the vast majority of measures required by 2030 along a zero-net emissions pathway

Although we have seen that a number of growth-enhancing mitigation actions are available to countries with large numbers of extremely poor people, we still have to examine how far this will take those countries toward a zero net emissions pathway. The exact pathway (size and timing) of emissions reduction 'required' by these countries is subject to considerable debate, often related to one's belief about a 'fair' division of responsibility between richer and poorer countries. In this study, we look at the reductions assumed in the most common scenarios (IEA and IPCC), without examining in depth how such actions might be funded. Such scenarios use different

35 The exception to these findings is a study conducted in India using a similar combination of energy system and macro-economic models (Planning Commission, 2014). This found that a 30% emissions reduction against BAU would lead to a fall in GDP of 3.3%. These results have yet to be reconciled with other studies analysed, but seem to point to the importance of utilising the fullest set of possible mitigation measures and having the technical and political capacity to implement them effectively.

36 The EWS looks at the impact of implementing *only* negative-cost, efficiency-enhancing mitigation actions. It does not assess the relative cost of additional measures. This study also did not look at non-energy-related emissions, hence it did not examine the full set of required emissions reductions, nor the full set of potential mitigation measures. The net impact of this omission is unclear.

37 BAU here refers to the 'Current Policies' scenario in IEA modelling.

criteria to determine how much each country should reduce emissions. However, they all call for relatively greater reductions in more developed countries and seek to prioritise the lowest cost options across countries.

The IEA's 450 Scenario shows developed countries reducing their GHG emissions by about 40% by 2030 against both current emission levels and BAU (since BAU involves only small fluctuations in emissions vs. today). For the rest of the developing world, it shows a reduction of about 10% by 2030 against current emission levels, but a 40% reduction against BAU. However, the reduction pathways assumed across the developing world vary greatly, based on the carbon intensity of their economy and differences in their state of development. For China, the 450 Scenario would see emissions fall by about 25% against current levels, and 50% against BAU. For LMICs, the 450 Scenario would actually see emissions continue to increase by 15-25% against current levels and fall by about 35-40% against BAU. Scenarios for LICs, especially Africa, are much less robust, since the pace and nature of their growth trajectory is far less certain and their contribution to global emissions to 2030 remains relatively small.[38] Here, we assume a 450 ppm pathway that is similar to the LMICs, with emissions increasing by 15% against current levels and falling by 25% against BAU.[39]

Figure 9 compares the amount of available growth-enhancing mitigation actions to the amount of mitigation 'required' for a 450ppm pathway, with both presented as a percentage reduction against a BAU scenario. Across Asia, we assume that emissions reductions of 33% vs. BAU are growth-enhancing, in line with the estimates above, although somewhat lower than the most optimistic estimates. In Africa, we make a more conservative assumption of 25%, in keeping with the fact that estimates are less certain and generally somewhat lower compared to Asia. The third column shows how much of the required mitigation is 'covered' by growth enhancing measures. For China, only about 66% of required reduction would be covered by such measures because of the large amount of mitigation China needs to achieve a zero-emissions pathway. For Africa, however, about 100% of required reductions could be achieved by growth-enhancing measures (although we must keep in mind that this assumes policy-makers will choose the optimal pathway and implement it efficiently).

Figure 9 suggests that most of the transitions on the pathway to zero net emissions up to 2030 are achievable with growth-enhancing actions for regions with high levels of extreme poverty, these studies do not fully consider the required sequencing of action and the possible need to undertake some higher-cost emissions reduction measures to avoid longer term lock-in to a higher emissions pathway. The full implications of a zero-emissions pathway are particularly hard to assess for countries like China and India, where 17-34% of the required measures are expected to be positive-cost or growth-reducing. Unfortunately, sector level and macroeconomic studies that robustly lay out this transition are not currently available, especially for countries with high levels of extreme poverty (Stern, 2013; NCE, 2014).

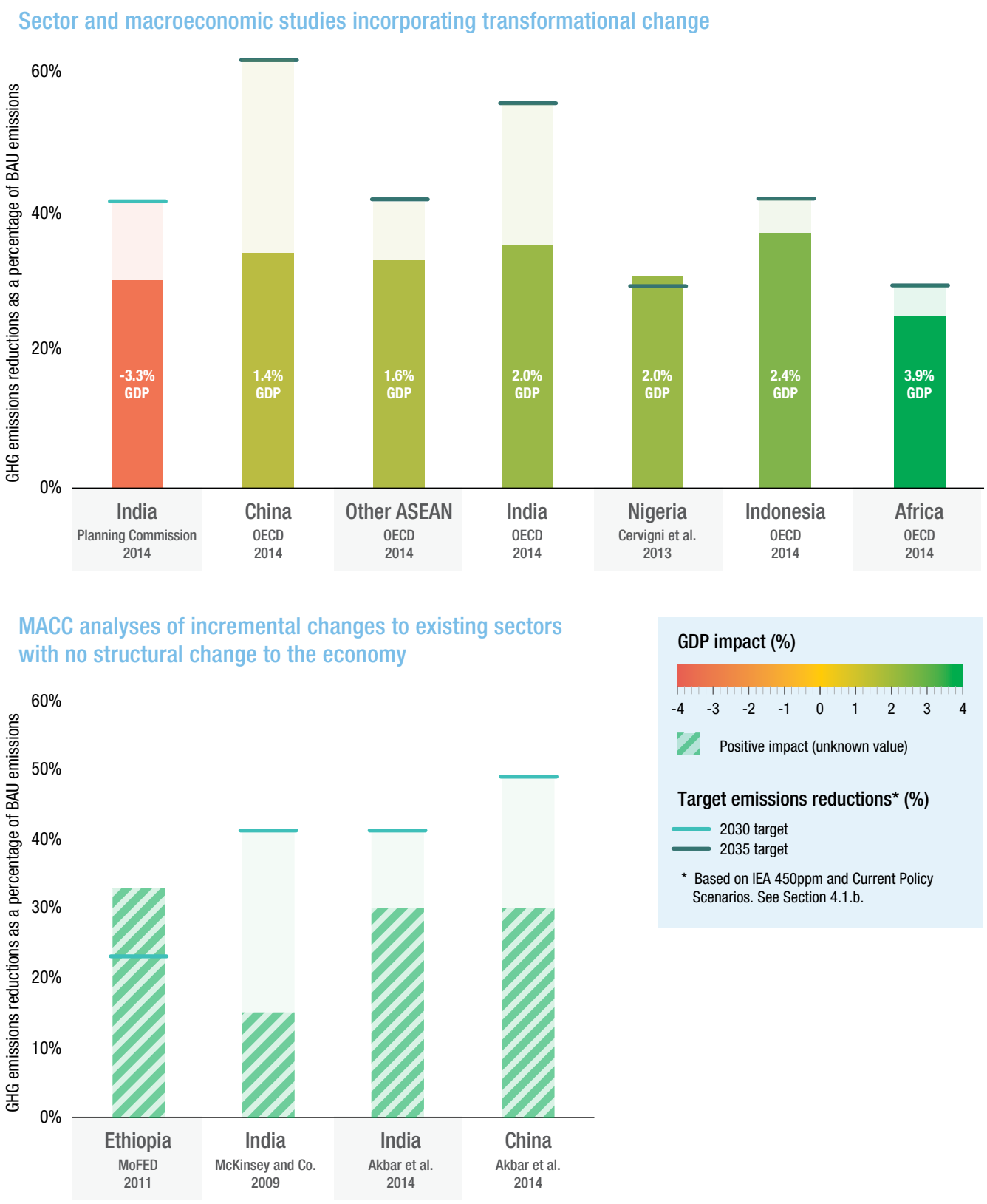
In contrast to the studies cited above identifying significant growth enhancing measures through to 2030, existing macroeconomic studies of the impact of moving to a net zero emissions pathway on growth up to 2050 tend to estimate impacts of +1% to -3% of GDP. These higher cost estimates effectively imply the loss of anywhere from 6 to 24 months of economic growth by 2030 compared to BAU; although this ignores the economic costs of climate impacts in that period (New Climate Economy, 2014). Such studies show the increasing, direct, net economic costs of emissions reduction measures as countries move closer towards zero emission economies—suggesting that both growth enhancing and growth inhibiting measures may be required by 2030, or shortly thereafter.

In the case of any given country, the benefits or costs could be much larger, depending on economic characteristics such as the nature of production, energy demand and the character of the energy, transport and building infrastructure. Moreover, a global shift to a zero-emissions pathway could create significant changes in the terms of trade of specific countries. For example, countries with large fossil-fuel exports might see their terms of trade deteriorate; or those able to reach a zero-emissions pathway with relatively low energy-supply costs might see the competitiveness of their manufacturing sector improve. Such dynamics are complex and can depend on the nature of international climate agreements. There is no inherent reason to believe poorer countries will, as a rule, suffer more from these relative effects. There are likely to be both winners and losers, and the impacts for particular countries are worthy of further study.

38 The IEA's 450 Scenario indicates relatively high reductions in emissions (37% against BAU), driven by the fact that a number of negative cost and relatively low cost abatement measures exist. Such a scenario implies that Africa 'leapfrogs' traditional patterns of energy sector development, with a very high level of institutional capacity and political foresight, as well as a robust international system of technological and financial transfers. In contrast, the IEA's recent 'Africa Century' scenario indicates continued increases in emissions through 2030 (7% growth vs. BAU) driven by relatively ambitious growth assumptions and a pattern of energy-sector development more similar to that of other countries to date. Given sub-Saharan Africa's very small contribution to emissions, global 450 ppm scenarios can include a fairly broad range for this region.

39 We have chosen an intermediate scenario, with levels of emissions reduction equal to those of the slowest acting LMICs, yet still relatively closer to the IEA's more stringent 450 Scenario. It would be valuable to have a much more thorough and well-constructed scenario for sub-Saharan Africa that takes into account the large number of growth-enhancing measures possible, the number of relatively cost-effective measures (from a global perspective) and the areas where it is most critical to avoid 'lock-in'. Although beyond the scope of this study, a rough review of the IEA scenarios suggests that the intermediate scenario chosen here could be consistent with a slightly modified global one for reaching a 450 ppm pathway.

Figure 9: Most of GHG emissions reductions in developing countries are growth enhancing



Analyses of developing Asia and Africa show that the low-emissions development necessary in the next two decades for a zero net emissions pathway is growth enhancing. The six most robust studies are shown grouped by methodology, with estimated growth impact indicatedwhere available.

2. A zero net emissions pathway can bring positive distributional impacts

A baseline of moderate, sustained economic growth will play a large role in facilitating and maintaining the eradication of extreme poverty. It is reassuring to see that a zero net emissions pathway can be conducive to such growth in countries with large numbers of extreme poor, even though some challenges may exist. Nevertheless, as we saw in Section 2, achieving zero extreme poverty by 2030 is likely to require a positive shift in how growth is distributed. For this reason, it is also important to consider how a zero net emission pathway might affect this distribution. There are two basic ways in which this occurs: emissions reduction pathways can (i) change the earnings of, or costs facing, the poor and (ii) change redistribution mechanisms to their benefit or detriment. In some cases, a win-win outcome may depend on a decision by policy makers to design emissions reduction actions that have a positive impact on the wellbeing of the poor.

a. The potential for zero emissions to improve the economic fundamentals facing the poor

Fundamentally, actions to achieve a zero net emissions pathway would be expected to reduce extreme poverty directly if they:

- increase the quantity and productivity of the labour of poor people
- increase the quantity and productivity of assets held by poor people
- increase the quantity and quality of public services to poor people and reduce the costs of accessing them
- reduce the cost of other goods and services consumed by poor people.

Whether specific mitigation actions also generate positive distributional benefits will depend significantly on a country's circumstances. There are very few studies that have looked at this question in detail, while none have assessed it systematically. Nevertheless, preliminary observations provide a sense of the inherent potential for such poverty-alleviation co-benefits. Perhaps more importantly, many mitigation actions seem to have the potential to contribute to poverty-alleviation, if structured with such a goal in mind.

There are a number of possible reasons for these co-benefits. First, mitigation actions could increase the productivity of the natural assets poor people disproportionately depend on for their livelihood and wellbeing. Factors such as improvements to crop rotations, minimum tillage, more precise use of fertilisers and agrochemicals and micro-irrigation increase the long-term productivity of land and reduce exposure to fluctuating input prices and potential water shortages. In addition, many climate-smart agriculture measures also build resilience to climate damages and reduce the risk that those damages will draw poor people deeper into poverty (FAO, 2013). Sustained productivity improvements in the agricultural sector have been critical to poverty eradication, making win-win opportunities of this sort particularly important.

Second, mitigation actions could increase the public services accessible by the poor, directly reducing the costs of transport or housing, indirectly enabling them to increase the quantity and productivity of their economic activity. For example, the poor are more likely to be able to access public transport compared to personal vehicle transport, where the latter involves a greater capital investment. Such access to transport can in turn increase access to (higher paying) employment and product markets.

Third, the promotion of renewables, which often have the biggest advantage vis-á-vis fossil-fuel alternatives in remote rural areas, can accelerate energy access for extremely poor people and provide a broader set of non-agricultural employment opportunities (UNDP, 2013). As we saw in Section 2, the development of infrastructure and public services (such as in energy) and employment opportunities that are more directed at poor people will be necessary to reach the goal of zero extreme poverty.

Fourth, the strong health co-benefits of climate action (e.g. from reduced air pollution and improved sanitation) should improve the immediate quantity and productivity of the labour of poor people in particular. This might improve their educational attainment and longer term productivity (Wheeler et al., 2010).

Finally, mitigation actions could eliminate poorly targeted redistribution mechanisms. One widely cited example is the elimination of the world's current high-carbon (e.g. fossil-fuel and fertiliser) subsidies, which benefit the rich disproportionately. Removing such subsidies and using the revenues gained will provide better targeted technical support or direct transfers to the poor. There would be both a reduction in emissions and a large impact on poverty alleviation at no net cost (World Bank, 2013; Clements et al., 2013; Independent Evaluation Group, 2008).

b. Mitigation options could be structured to benefit poor people in particular through policy design

It is worth recognising that a number of mitigation actions could favour the better-off disproportionately or even harm poor people directly. First, many mitigation actions would improve the quality of capital assets, such as building and industrial efficiency, that tend to be owned by the better off. Second, while public service related actions, such as improved public transport or waste disposal, are inherently redistributive (since they are paid for by the tax payer, but available to most of the population), they are still more likely to serve the relatively better off; they also may neglect the needs of the very poor in some cases. Third, a number of actions could increase the prices of goods and services on which poor people spend a large portion of their income, including food and energy. Finally,

measures to remove subsidies on goods consumed by poor people, such as fossil fuels and fertiliser, can harm them if there is no compensation for subsidy removal through other transfer methods.

However, most mitigation actions that could favour the better off can be structured and implemented to ensure absolute (and in some cases relative) benefits to poor people. Lower-carbon services like public transport and waste disposal can provide relatively more benefit to poor people who cannot afford private vehicles or who are trying to avoid unsanitary waste sites. However, this means project choice, design and implementation must try to optimise these benefits, such as by ensuring services reach poorer and often informal settlements, and that pricing schemes are affordable to those with low-incomes.

Similarly, programmes to improve physical assets like buildings and land can be designed to ensure maximum uptake by, and benefit to, poor people. Such programmes might also help drive the formalisation of property rights, benefiting many of the extreme poor (Meinzen-Dick, 2009; Galiania and Schargrodskyb, 2010). This is crucial, as we have seen the importance of accumulating capital assets to reach sustained poverty eradication. The public sector can also leverage its ability to undertake and redirect capital toward projects that are capital intensive but yield long lasting and deep results in terms of emissions reductions, crop yield increases and poverty alleviation. One such example is the Loess Plateau project in China, which led to 2.5m people being lifted out of poverty as a result of investment in improved farm practice and land restoration activities (New Climate Economy, 2014).

If actions aimed at zero emission are well-integrated into a more comprehensive zero-poverty strategy, co-benefits for poverty-alleviation seem possible without otherwise reducing the benefits or increasing the costs of mitigation. From the perspective of poverty alleviation, the complementary actions to ensure zero-emissions actions are pro-poor are exactly the same as actions that should be targeted by poverty-alleviation policies: robust and efficient transfer mechanisms, policies to increase poor people's access to public services and programmes to increase their access to finance and their ability to accumulate assets. Table 3 sets out some key mitigation actions, their potential distributional impact on the extreme poor and additional policy considerations to ensure they are truly pro-poor.

3. Achieving Zero Zero requires transitions in three major economic and social systems

The achievement of zero net emissions will require a significant structural shift in major economic and social systems in three areas: how we produce and consume energy, how we produce and consume food and how we arrange, plan and build human habitat. They parallel the transitions needed in energy, land use and cities highlighted in the New Climate Economy Report (NCE, 2014). However, this paper focuses on the added ambition needed to make these transitions serve the poor. Detailed analysis of each transition deserves much further dedicated analysis than can be provided in this single report.

Even though the two goals of zero extreme poverty and zero net emissions may align very readily in many cases, pursuing both simultaneously will require politically tough choices about which development pathways we can rely upon to achieve lasting poverty reduction. Energy access can mean access to national energy capacity for industrialisation and growth, or it can mean direct household access to modern cooking and electricity. Agricultural productivity can mean agro-industrialisation to maximise on-farm output, or it can mean promoting climate-smart agriculture in the small and medium-sized farms employing so many of the rural poor. Urbanisation holds the promise of more compact and efficient human habitat, with better access to economic opportunity and public services; it can mean cities are overwhelmed by human need and vulnerability or make cities capable of planning urban forms to better meet human needs in a changing climate. In each of these transitions, what we mean, along with what we prioritise and how, has major implications for the rapid eradication of extreme poverty, both for our emissions and climate trajectory and other policy priorities.

a. The agricultural transition

Agriculture is an essential component in any discussion about global poverty reduction. Farming is the mainstay of many of the poorest people in the world, most of whom are rural-based farmers, while rural areas account for 75% of people living on less than $1 per day (UNDP 2007). Recent declines in the poverty rate have been the result, primarily, of falling rural poverty rather than urban poverty and much of this decline relates to better conditions in rural areas rather than migration to cities (World Bank, 2008). Enough food is currently being produced to feed the global population, although food security and hunger remain, demonstrating the poor distribution of the world's food. An additional challenge is the sufficient production of food in the future; with projected population increases and shifts in dietary demand, agricultural production will need to increase significantly to maintain, let alone improve, current levels of food security. This is especially the case, given that the global population will grow by a further third by 2050.

In agriculture-based countries, where most poor people live in rural areas and agriculture accounts for about one-third of GDP, agriculture is therefore still the sector with the greatest potential for overall economic growth and poverty reduction. Where productivity and economic growth is the primary policy goal, agricultural policy has often focused on large-scale intensified agriculture

and livestock, particularly in land-abundant developing countries. This approach involves appropriating land or amalgamating small farms for production maximisation, economies of scale and increasing agro-industrial processing. These often integrate vertically in the sector with processing, marketing and export activities, as well as horizontally, with corporations controlling hundreds of thousands of hectares. Such an approach provides greater access for investors and benefits from economies of scale, but implies a need for large-scale energy infrastructure and greater regionalisation of trade.

While agro-industrial consolidation can prove profitable, and thus drive growth, it is not necessarily equitable. In the absence of strong governance and redistributive regulatory systems, this approach may hinder progress toward the zero extreme poverty goal. As noted early in this paper, poverty reduction will require both sustained growth and policy approaches that reduce inequality. Instead, a focus on growth through smallholder productivity is considered the most robust way to stimulate poverty reduction: 'improving the productivity, profitability and sustainability of smallholder farming is the main pathway out of poverty in using agriculture for development' (World Bank, 2008, p. 10). Productivity gains for agricultural smallholders also provide a foundation for the more equitable distribution of economic growth.

There is also significant evidence that small farms work: they are generally relatively more productive per hectare than large scale plantations (UNEP, 2013). Sustainable smallholder agriculture provides a potential poverty-reducing pathway towards Zero Zero, but faces the challenge of increasing its productivity among the poorest countries of the world. While there are demonstrations of significant increases in yields from sustainable agriculture

Table 3. Examples of climate mitigation actions and their impact on the livelihoods of the extreme poor

Mitigation action	Impact on the livelihoods of the extreme poor	Additional pro-poor considerations
Climate-smart agriculture practices	Direct increase of agricultural productivity and income for those in extreme poverty. Direct increase in the value of land for poor land-owners. Increased resilience and reduced risk of large income fluctuations.	Benefits dependent on the availability of financing and technical capabilities for those in extreme poverty. Most effective when combined with the formalisation of land rights.
Preserving and increasing natural carbon sinks	Job and income creation or enhancement for those reliant on forest products. Increase in the value of land for poor land-owners benefiting from associated eco-system services (e.g. water regulation, soil conservation).	Job and income creation targeted at those who may have lost source of livelihood through forest preservation.
Increased public transport	Reduction in health-related costs from air pollution. Greater mobility at lower cost, which expands employment opportunities and net benefits.	Public transport designed and priced to ensure that benefits accrue to those in extreme poverty.
Low-emissions waste management	Reduction in health-related costs from poor sanitation.	Waste treatment priced to ensure that benefits accrue to those in extreme poverty.
Energy-efficient residential buildings	Reduced long-terms cost of housing and related services. Improved asset value for the home-owning poor.	Benefits dependent on the availability of financing and technical capabilities for those in extreme poverty. Most effective when combined with the formalisation of property rights.
Distributed renewable energy (electric and household thermal)	Reduction in health-related costs from indoor pollution. Access to energy at lower cost than high-carbon alternatives.	Distributed renewable energy may be limited to providing energy services that only meet basic needs
Centralised renewable energy (electric and thermal)	Reduction in health-related costs from ambient air pollution when replacing coal-fired generation. Job creation (IRENA). Higher cost of energy could have a negative impact on the resources of those in extreme poverty.	Avoiding impacts on energy prices would require compensation through other mechanisms.
Increased bio-energy (power or transport)	Higher agricultural crop prices could improve the incomes of poor farmers. Higher food prices could have a negative impact on those in extreme poverty in urban areas	Avoiding impacts on food prices would require clear restrictions on where bio-energy crops are grown.
Reduced subsidies for fossil fuels and agricultural inputs (including fertilisers)	Better-targeted technical and cash transfers increase the income of those in extreme poverty.	Dependent on replacing regressive subsidies with better-targeted assistance.

techniques and lower emission approaches, this is no small task to accomplish at scale. Is the same sort of success possible amongst the 500 million smallholders of the world? This remains a challenge.

Improving productivity, particularly among small farms, could present a major synergy for the reductions of both emissions and poverty, where there is the institutional capacity and political will to limit the land-use conversion of forests and other natural stores of GHGs. Even if sustainable intensification on small farms provides productivity increases that can directly reduce extreme poverty, there are still further steps in the agricultural system that present opportunities for significant emissions reductions compatible with a zero net emissions target.

Agriculture is already responsible for a significant amount of GHG emissions. Increasing crop production globally means the agriculture, forestry and other land uses are now responsible for around 25% of total GHG emissions. Agriculture and other land use sectors [40] face great technical challenges to improving their efficiency and reduce emissions, and an entrenched assumption that natural resources can continue to be depleted with limited near-term impacts. This leads to uncertainty in terms of the potential costs and benefits of mitigation action. A sizeable portion of this results from significant dependence on fossil fuels for mechanised and chemical inputs and extensification (IPCC, 2014a). Low-carbon agriculture requires a move away from increasing inputs like fertilisers and pesticides, better livestock management, and increasing technical inputs that improve the efficiency of water and fertiliser inputs, conserve and improve the quality of the soil and make better use of residues and post-harvest waste.

In the forest sector, it requires a shift from the extractive use of primary forest to the sustainable management of primary forest and plantation-based reforestation of deforested areas. It will also require that productivity and intensification are 'bounded' by effective land use governance to ensure that increased yields do not translate into increased forest conversion. This requires a broad increase in both the physical and human-capital investments made in land-use sectors in poor countries. For some actions, it is also likely to require increased public spending and significant international support.

Many land-use emissions reduction measures do appear to be relatively affordable, if not net negative cost. Agricultural emissions in India, Ethiopia and Nigeria could be reduced by about 50% or more (vs. BAU) through actions costing <€20 per tonne, with significant negative cost opportunities found in Ethiopia and Nigeria (MoFED, 2011; McKinsey and Co, 2009; Cervigni et al., 2013). Encouragingly, these studies also suggest that the required increases in food production are still achievable while reducing emissions and that emissions reduction should not, on balance, increase the price of food. There is also significant overlap in the types of measures required to reduce emissions and those required to increase climate resilience.

In the forest sector, emissions reductions equivalent to about 3-25% of total BAU emissions could be available through actions costing <€20 per tonne, with the potential for negative cost opportunities through forest plantations.[41] There is also scope for growth enhancing mitigation opportunities in the sector. However, these will require structural shifts in the existing growth pattern and the use of primary forests, both of which might require a broad increase in physical and human capital investments, with increased public spending and significant international support for some actions.

At the same time, given the climate-sensitivity of the agriculture sector, some diversification of livelihoods away from agriculture may eventually be important for extreme poverty reduction (DFID, 2004). But the scale of the transformation necessary to shift land-based rural poor people into other economic sectors is both enormous and complicated by how other aspects of transformation are being managed. Wider changes into alternative livelihoods for the rural poor would require commitment and investment from government, significant increases in skills and capacity and greater social protection alongside strong governance of those who are unable to benefit from these changes.

It is necessary to align both the poverty and emissions reduction goals within agriculture and reorient away from 'least resistance' BAU pathways for agricultural productivity. Even with some identified synergies between the Zero Zero goals, this will require an unprecedented investment in both human and natural capital, agricultural techniques, innovations and technologies, and strong political engagement. A zero extreme poverty agricultural transformation must either greatly expand the resource productivity and employment opportunities within the sector and at scale or enable a significant and unprecedented demographic shift away from agricultural jobs without creating further poverty. A zero net emissions pathway for an agricultural transformation will require intensification. This would need to take place alongside significant institutional capacity capable of reining in

40 Technically referred to as Agriculture, Forestry and Other Land Uses (or AFOLU).

41 These represent very rough estimates, as the BAU assumptions vary greatly across studies. With regard to negative emissions in the forest sector, it is worth noting the significant variation between countries like Ethiopia, where potential negative emissions from afforestation and reforestation opportunities could represent a large proportion (25%) of emissions reductions, and countries like India and Nigeria, where the opportunity is more modest (<5-10%).

extensification where land-use conversion creates an unsustainable emissions pathway.

b. The human habitat transition

As cities become the primary form of human habitat, they also become critical for reaching the Zero Zero goal. It is the developing regions that house the majority of the world's poor that will experience the most significant urban change. Cities are also centres of current and future global emissions. Less than 500 cities will account for half the growth in energy-related GHG emissions between now and 2030 (NCE, 2014); virtually all of those are in developing countries.

Within the broader economic narrative, cities are regarded as 'engines of growth'; they contribute 80% to global GDP and will account for most of global income growth between now and 2030 (NCE, 2014). Cities can also boost resource productivity and efficiency through smart investments in energy, waste and transit systems. Such investments, coupled with population density, can provide high per capita GHG efficiency. On the other hand, the urban poor often face the worst consequences of haphazard development patterns, the same patterns that continue to drive up urban GHG emissions. Ravallion et al. (2007) note that even though urbanisation plays a positive role in overall poverty reduction, the urban share of poor people is rising. They also suggest poorly planned urbanisation can entrench patterns of poverty and inequality. Leveraging the advantages of concentration, proximity and scale means cities can play a key role in both accelerating the move of hundreds of millions of people out of poverty and ensuring a low-cost, zero net emissions transition. Yet despite strong inherent potential, and sometimes quite positive tendencies, we cannot rely on urbanisation in and of itself to drive growth, eradicate poverty and reduce emissions.

Urban development may be the most extreme example of a large inherent opportunity facing a large implementation challenge. There is significant evidence that compact and connected urban forms have noteworthy economic, social and environmental impacts. Nevertheless, there is sophisticated and farsighted planning required to create this; this combines with enormous investment commitments, inertia of incumbent political interests and the rapidly changing situation on the ground to leave many cities either paralysed or perennially behind the curve.

Still, there is no fundamental trade-off between growth and emissions reductions in these sectors, provided short term action is taken with the long-term goal in mind and the institutional capacity and necessary financing is available. Buildings, industry, waste and transport sectors generally have broad, and often quite strong, growth-enhancing impacts.[42] This is an important insight and stems from the fact these sectors have large efficiency improvement opportunities and/or large co-benefits from mitigation. Examples of this include reduced air pollution, reduced congestion and improved sanitation. However, even within these clearly net negative cost sectors, there are challenges.

In the coming decades, the urban transition could take a number of different directions: urban spaces could entrench and perpetuate old problems for new people or drive a radical transformation by 2030 and beyond. Opportunities exist to design more compact, better-connected cities, while the construction of durable, efficient infrastructure could both improve the condition of the urban poor and reduce emissions. Shaping this transition in ways that both improve the quality of life of the poor and the quality of the environment is contingent upon a targeted and cross-sectoral approach to urban development. It also utilises a bundle of policy instruments to address its many dimensions.

Cities face fundamental choices. They can continue to expand and magnify socio-spatial disparities, while testing the limits of public infrastructure, or they can act as real game-changers in altering the course of urban development. In the short term, they can a) prioritise the poverty or climate exigency and thereby make it even more difficult to achieve both or b) tackle the two issues together with greater efficacy. To achieve the goals of Zero Zero, the urban transformation should fundamentally and permanently alter people's relationships to space, economy and ecology by closely weaving the three together into one cohesive human 'habitat'. Urbanisation can drive these positive transformations, but only when planners and policymakers have the will, vision and capacity to enable this change.

From this perspective, the best concept of 'cities' incorporates a deliberate linking of spatial planning with public policy goals that encompass both emissions reductions and poverty alleviation. Made up fundamentally of great spaces—public and private—'liveable' cities should have places for people at all income levels to live, work and play: streets that are not congested with traffic and pollution, but rather walkable and diverse. They also require basic services that are reliable, affordable and clean (Evenden, 2014).

42 An important potential exception to this is China, which has the biggest mitigation challenge of any country with significant numbers of people still in extreme poverty. In this case, it may be that relatively higher cost measures in these sectors will be required to meet the 50% reduction required for a global 450 ppm scenario. China is perhaps the one country reviewed in this study where there appears to be a strong probability of a net negative macroeconomic impact from a zero net emissions pathway to 2030.

The need for compact, connected, coordinated and inclusive urban growth is particularly needed in rapidly urbanising, often poorer countries such as India, where 70 to 80% of urban infrastructure is yet to be built (NCE, 2014). Achieving this objective in developing countries, which are currently overwhelmed by the speed and scale of urbanisation, will require a holistic approach to planning and significant improvements in the capacity and financial resources of cities. However, if planning is explicitly aimed at ensuring growth, emissions reductions and poverty eradication, the strong fundamental complementarities of such a model can catapult us to a Zero Zero world.

c. The energy transition

Energy for electricity, to drive machinery and generate heat is a critical enabler of economic growth—rising energy-use per capita always accompanies rising income per capita in the early stages of development. Historically, rising energy use has also been coupled with GHG emissions and energy consumption now accounts for about 40% of global emissions (Foster and Bedrosyen, 2014). All scenarios for zero net emissions require decarbonisation of the energy system, involving a major transition away from coal and other non-renewable energy sources and toward renewable energy sources (IPCC, 2014b). In parallel, reaching zero extreme poverty will require a major expansion of, and more equitable, energy access during this transition. Lack of direct energy access[43] contributes to both income and multi-dimensional poverty. Providing poor households with access to secure and reliable energy can improve their economic productivity and access to information, education and health (Hogarth and Granoff, 2015; Lockwood and Pueyo, 2013).

'Sustainable energy access' is widely regarded as an important policy solution for the achievement of the Zero Zero goals. Yet, the term 'sustainable energy access' fails to distinguish between major policy choices and technology options, each of which has distinct pathways to poverty reduction and different impacts on the achievement of zero net emissions. Energy access, availability, energy consumption and installed capacity represent distinct elements of the energy system. Similarly, electricity and energy are different: the latter includes critical components of the household energy mix that are not often substituted by electricity in the developing world, particularly thermal energy for cooking and heating. Using the terms interchangeably can confuse policy choices and a better understanding of these options sheds light not only on potential fixes, but also on the impacts of different energy transitions on poverty reduction.

The degree to which increasing access to distributed energy can provide the full range of energy services needed for development is still disputed. However, there are strong reasons to pursue this as an immediate priority to reduce poverty (Craine et al., 2014). Distributed household energy access—thermal and electric—can move the poor up the energy 'ladder'. This can be done at reasonable cost and with few implications for emissions if renewable technologies continue to dominate off-grid energy systems and if greater attention is paid to the poverty-reduction benefits of prioritising improvements in household thermal-energy access. Similarly, while the extension of the central grid to improve access has more potential trade-offs vis-a-vis emissions reductions, the additional emissions are relatively small compared to the poverty-reduction benefits, even in a high-carbon system. This trade-off should in no way inhibit our efforts to address the direct energy access challenge immediately. A larger trade-off arises in addressing the energy generation gap for industrialisation and for expanded consumption of more well-off energy consumers.

There is a need for a specific focus on the expansion of direct access, through a combination of distributed energy and expanded distribution networks. This is a necessary compliment to the longer-term poverty alleviation that may come from 'converting' industrialisation-led growth from high levels of generation expansion into the reduction of extreme poverty. Industrial generation is still crucial for the longer-term scenario of sustained growth and improving welfare across all income groups; here, a managed decarbonisation presents greater policy challenges and clean energy ambition.

The large scale expansion of energy capacity to meet the growing demands of industrialisation and the non-poor in developing countries are crucial public-policy challenges that can also have significant impacts on poverty reduction. Reducing emissions while scaling-up supply continues to represent the biggest challenge in terms of the relatively high underlying cost of emissions reductions, along with the large physical capital investment required, though with large variations of impact across countries here as well. It drives the negative GDP impacts found in most studies. Also, for some countries (especially MICs), it is conceivable these costs could add up to a few percentage points of GDP by 2030. The challenge of raising sufficient capital is both a hurdle in itself, as well as a driver of additional costs in many cases; for countries with insufficient domestic capital, low credit rating and high currency fluctuations, the cost of renewables can be greater by c.25% (NCE, 2014). Overcoming the trade-offs in energy supply will be critical in India and China – the two countries that stand out as having large numbers of extremely poor people while also emitting large amounts of GHGs from their energy sectors. In the case of India, there is the additional, distinct challenge of providing direct electricity access to around 400 million people who currently lack it.

In recent years however, the energy-supply sector has shown a steady improvement in the cost of both low-carbon technologies and financing, with renewable energy prices dropping significantly over the past 5 years, while the full cost of high-carbon energy supply has become more apparent. The energy sector's capacity to procure and integrate utility-scale renewables has improved markedly in the last decade.

Together with the technical and financing progress of off-grid energy discussed above lead to an increasing number of negative-cost opportunities in some countries.

Although evidence is limited, such growth-enhancing and low-carbon energy supply opportunities can represent a large share of the necessary action on energy supply decarbonisation in some developing countries, especially the LDCs (e.g. well over 50% in Nigeria) (Cervigni et al., 2013). In addition, more suitable financing instruments for renewable projects are being introduced. These have the potential to be scaled up rapidly over the next few years to reduce a large portion of the additional financing burden.

But even in countries where energy sector emissions reductions might come at a positive cost, such as India and China, it may still be preferable to the costs associated with continued development in high-carbon infrastructure. These include the externality costs of coal (e.g. air pollution and water use) and the risks of stranded assets. India and China currently face air pollution levels many times higher than WHO recommendations, and their power plant construction plans would create hundreds of billions of dollars of assets that would be stranded in the case of a rapid transition to a zero-emissions pathway (NCE, 2014).

Overall, with a 15-year time horizon and an ethical imperative to shift the poorest people out of abject poverty, specific policy priorities delivering services to the extreme poor are needed to improve their consumption and wellbeing at speed. Off-grid energy provides an enormous win-win opportunity for poverty reduction and climate change.

The scale-up of energy supply faces the most formidable climate challenge, but has clear limits in terms of addressing the energy access issues of the poor, particularly the rural poor. A transition of large-scale energy supply in the developing world has the potential to slow growth. But this impact appears to be very small in LDCs that have both less immediate need to decarbonise their energy supply, and a relatively larger proportion of negative-cost opportunities. In middle-income countries (that still have large numbers of extreme poor), especially India and China, the cost might be higher, but estimates suggest that it is manageable, and too small to interfere with the moderate and sustained economic growth required to facilitate poverty eradication in those countries. As with land use, the successful management of the trade-offs and the achievement of growth-friendly mitigation will require major increases in both human and physical capital, and will, in many cases, also require increased public spending and international support.

43 'Direct' energy access refers to energy access reaching actual individuals and households, as opposed to individuals indirectly benefiting from the role of energy in the larger economy (such as via products from manufacturing, jobs).

5. Conclusions

1. Targeting Zero Zero is critical to sustained poverty eradication

The international development community needs clear priorities in order to direct a critical mass of resources, attention and focus toward the biggest global challenges. That poverty and development are multidimensional and complex issues is reflected in the breadth of the proposed Sustainable Development Goals. However, while the goals are rich in nuance, they are poor in focus. Two targets - zero poverty by 2030 and zero net emissions by 2100 – provides an ambitious framework with the focus needed to drive progress.

In the post-2015 development agenda, the sustained eradication of extreme poverty is the minimum ethical floor of global development, and the central target underpinning the Sustainable Development Goals (Open Working Group of the General Assembly on Sustainable Development Goals, 2014). Progress over the past two decades has reduced extreme poverty from 43% of the developing world's population to 17%. Projections suggest eradication is possible by 2030, making the goal of 'zero extreme poverty by 2030' a compelling objective. Climate change, however, is a destabilising force that has yet to be factored in, not only to poverty projections to 2030, but projections that look beyond that deadline.

The eradication of extreme poverty by 2030 will be no great accomplishment if we are incapable of sustaining that achievement. Climate change will hit the very poorest hardest and threatens to undo many of the hard-fought development gains achieved in recent decades. It will make it harder for people to escape extreme poverty and will require even greater ambition to ensure the resilience and longevity of the poverty reductions achieved.

Curbing climate change so that impacts are manageable will require the global economy to produce zero net emissions before 2100. Adopting a goal for zero net emissions, even by the end of the century, has immediate implications for action, as cumulative global emissions must peak by around 2030—the same timeframe as that for eradication of extreme poverty. To achieve this target, all countries need to take urgent action to shift their economies towards models with very low GHG emissions. Developed countries must make the deepest and most immediate cuts against their current emissions. However, even middle and low-income countries will need to ensure their current investment choices reduce their forecast emissions and anticipate a future peak and decline in emissions as part of their development path. Even if we achieve this transition, countries will need to adapt to already locked-in climate change to limit the impact on the poor.

The economic transformation required to achieve a zero net emissions pathway presents an additional global challenge that is sometimes thought to conflict with the goal of zero extreme poverty. However, contrary to these assertions, this paper finds that the goal of zero net emissions is compatible with eradicating extreme poverty. Early evidence suggests low-emission economic development, although radically different from our historical experience, is consistent with the combination of moderate, sustained growth and reductions in inequality needed to eradicate poverty. Unchecked climate change impacts will create a significant challenge for the zero poverty target, but climate change mitigation need not.

2. Achieving Zero Zero will not be easy

Although a broadly positive picture has emerged of the compatibility of a zero-emissions pathway with the eradication of extreme poverty, a number of critical challenges will not be easy to overcome—particularly in poor countries. These include the need for large amounts of investment capital, significant improvements to institutional capacity and a major expansion of technical skills—all of which are urgent, present-day priorities in order to set underway the transformations that are needed by 2030.

Work by the IEA suggests countries with large numbers of people in extreme poverty will require about $5 trillion in investment for measures related to energy efficiency by 2030. Meanwhile, another $1-2 trillion will be needed for investment in clean energy if those people are to reach zero net emissions. Work by the FAO suggests an additional $200 billion could be required for actions related to the agriculture sector in Africa alone (Branca et al., 2012); this amount could easily double if India and Southeast Asia were incorporated too. A recent analysis by the NCE suggests the reductions in other investment requirements

44 Total gross capital formation in sub-Saharan Africa and India was roughly $1 trillion in 2013, while total gross capital formation across all low and lower-middle income countries was only about $1.5 trillion in 2013 (World Bank, 2014b).

(such as infrastructure related to fossil fuels) could cut this amount in half to two-thirds. Nevertheless, an incremental increase in required capital investment of even $2-4 trillion is significant[45]; especially considering that much of it is required in countries that are perennially short of any capital to invest. In addition, as the previous section has made clear, pro-poor climate action requires not just an increase in aggregate investment capital, but also an increase in the availability of that capital to poor people – an added complication to an already enormous challenge.

If a target of zero net emissions can help accelerate existing efforts to provide capital to poor countries, as well as increase poor people's access to that capital, then focusing policy on the compatibility of these goals could be a healthy pressure, putting more force behind efforts to overcome these fundamental challenges. Climate finance could be used to this end. It needs to be scaled up to meet the needs of countries with sizeable numbers of extremely poor people, transforming development finance to create a win-win outcome. At the same time, care is needed to ensure extremely poor people are not excluded from new capital flows.

Another key challenge will be the creation of the institutional capacity and technical skills required to develop adequate policies, deploy investment capital, implement low-carbon programmes and manage low-carbon enterprises. Experience in developed countries over the past decade shows that these 'transaction costs' can be significant (ESMAP, 2009). Furthermore, when action is taken on mitigation actions without adequate institutional capacity and technical skills already in place, the cost of sub-optimal decisions is likely to soar (Averchenkova, 2014). So, while a pathway towards zero net emissions could improve the prospects for economic growth in poorer countries, the achievement of this dual goal is by no means assured.

Similarly, achieving the pro-poor outcomes discussed in this paper requires far stronger institutional capacities to deliver compensatory transfers effectively to poor people, along with services designed to meet their needs from the outset. Experience here is mixed. For example, efforts to reduce fossil-fuel subsidies while compensating poor people for losses to their wellbeing have failed in many cases (Clements et al., 2013). It is also clear that pro-poor outcomes require more than improved technical capacity: that facility needs to be delivered to poor people so they can feel its benefits—decades of experience with 'extension services' has shown this is not an easy task, nor is success guaranteed (David and Hlungwani, 2014). Once again, if a target for zero net emissions can provide additional impetus to improve these fundamental institutional and technical capacities, then a Zero Zero goal could create a virtuous cycle. But care must be taken to scale up such capacities and skills, and not simply put further strain on already scarce institutions and individuals.

One inescapable fact is the sheer scale of the structural transformation and related policy ambitions that are needed to achieve either of the zero goals. Even if the ethics of eradicating extreme poverty are clear enough, the interests of extremely poor people align only partially—at best—with the interests of those who hold political power. Reducing inequality and poverty are political processes rather than technical ones (Leftwich, 2008, draft). Even where low-carbon choices entail clear negative costs and large social benefits, the entrenchment of BAU pathways can make the necessary transitions costly in political terms (Bailey and Preston, 2014; Geels, 2014). This means that meeting the combined policy goals of zero extreme poverty and zero net emissions will require policy choices that are not always politically easy or palatable. Climate actions toward zero net emissions may, inevitably, run counter to short-term poverty-eradication efforts in some areas, even if a zero net emissions trajectory is necessary to sustain poverty reductions in the long-term, beyond 2030. Nevertheless, this paper has aimed to introduce some perspectives on the necessity and compatibility of tackling both zero extreme poverty and zero net emissions simultaneously.

3. Reaching Zero Zero is possible

The eradication of extreme poverty is, in one sense, unrelated to the achievement of zero net emissions. A very small portion of total economic growth would need to be distributed toward poor people to eradicate poverty, which would have little, if any, net impact on GHG emissions. Similarly, some of the most powerful levers for the sustained reduction of poverty—education, health services and clean water, for example—have only a small impact on GHG emissions.

In another sense, however, the eradication of extreme poverty depends on the achievement of zero net emissions. This paper has illustrated the additional burden that continued climate change would place on poverty eradication, and the plausible scenarios in which the climate change associated with a BAU scenario will create persistent and irremediable poverty. That unmitigated climate change and poverty reduction are incompatible appears to be true even if the world succeeds in ensuring that economic growth benefits poor people. It will be even truer if the world is slower to eradicate poverty and if many more hundreds of millions of people remain impoverished well into the second half of the century. It will even remain true if the world undertakes significant adaptation measures—the evidence suggests that the required additional adaptation measures would be both costly (perhaps in the order of 1% of GDP in 2030 for

45 Total gross capital formation in sub-Saharan Africa and India was roughly $1 trillion in 2013, while total gross capital formation across all low and lower-middle income countries was only about $1.5 trillion in 2013 (World Bank, 2014b).

the least-developed countries) and only partially effective. Action toward zero net emissions, globally, is critical.

In contrast, a pathway toward zero net emissions has a number of broadly positive benefits for poverty reduction, both in terms of enhancing overall economic growth and in improving the distribution of that growth. While growth-focused approaches run the risk of driving large increases in emissions (i.e. the growth of the middle class and industry, as seen in China), they don't necessarily have to.

Even pessimistic assessments of the costs of climate action show manageable growth impacts (perhaps 3-5% of GDP by 2030). More recent evidence points to the possibility of pro-growth transformational change, where climate action drives stronger growth (e.g. NCE, 2014). In many countries, climate action could also drive a stronger growth trajectory by increasing infrastructure investment and improving infrastructure choices, managing natural capital better and increasing productivity and competitiveness. It could also achieve growth by potentially increasing energy security and diversifying the productive base.

Importantly, the greatest potential for a pro-growth, lower-carbon pathway is found in the LDCs. Estimates continue to vary widely, but recent evidence suggests climate action could generate a modest increase in growth (perhaps by around 1% by 2030) for the LDCs, while reducing growth only moderately (perhaps by around 1-3%) for the LMICs. It is not impossible that global climate mitigation could be cheaper than adaptation even in the relative short term (i.e. to 2050), at least in relation to the LDCs. [46]

Indeed, a strategy focused on equitable growth to eradicate poverty could complement the structural changes involved in a pathway toward zero net emissions. Although climate action is not always necessarily pro-poor, it has the potential to reinforce efforts to generate equitable growth if a combined Zero Zero pathway can be fully integrated. If this is done correctly, climate action could serve as a major impetus for improvements in poor people's human capital, productive assets and access to basic services. Climate action could reinforce the core drivers of poverty eradication while remaining compatible with the moderate and sustained economic growth necessary to move to-and-through zero extreme poverty. Even where unavoidable trade-offs exist, they appear to be relatively smaller and very manageable, especially for LDCs in the context of international support. However, to manage a Zero Zero pathway effectively, these countries will require far more capital, with far greater institutional capacity and technical skills than they have at present. Building this capacity represents a significant challenge to be overcome.

One thing is clear, however: neither of the goals—zero extreme poverty nor zero net emissions—are compatible with business-as-usual. Reaching zero extreme poverty and maintaining progress toward zero net emissions will, first and foremost, require fundamental structural shifts in major economic systems. Addressing poverty and climate challenges together offers the opportunity for a single, robust and mutually reinforcing transition. Tackling them separately seems likely to be far less effective. Domestic and international aid priorities must therefore focus on a combined Zero Zero pathway. The need for international climate support remains immense. This analysis suggests the returns to this support, in terms of growth and poverty reduction in poorer countries, as well as lower global emissions, will also be immense, provided it is well-directed toward combined and transformational change.

Policy implications

To achieve lasting zero poverty, development efforts must be more pro-poor and low-emission. In policy terms, this implies that:

- **Poverty eradication is possible by 2030, through growth and reductions in inequality.** Economic growth in developing countries is crucial for poverty eradication, but it is not enough. Addressing growth and inequality together is far more likely to reduce poverty, requiring targeted measures that focus on the building poor people's human capital (through nutrition, health and education), their opportunity to accumulate assets, and their access to infrastructure, services, jobs, and political representation. Efforts to eradicate poverty will also need to contend with the impacts of climate change.

- **Poverty eradication cannot be maintained without deep cuts from the big GHG emitters.** It is policy incoherent for big GHG emitting countries, especially industrialized countries, to support poverty eradication as a development priority, whether through domestic policy or international assistance, while failing to shift their own economy toward a zero net emissions pathway. Developed countries that want to show leadership in fighting extreme poverty globally need to cut domestic emissions to deliver on their ambition, and also redouble their efforts to support developing countries to achieve low-carbon, resilient development.

- **Low carbon development is both necessary for, and compatible with, poverty eradication.** Emerging economies need to plan for peaking emissions and a zero net emissions target. There is an increasing body

46 This does not mean that mitigation is cheaper than adaptation in the short-term *globally*. As we've seen, the costs of mitigation are more likely to be positive (even if modest) for MICs and developed countries by 2030, while these countries may have a higher level of relative resilience to climate impacts at or below 2°C. We have not examined this question in this paper.

of evidence showing that many, if not most, emissions reductions opportunities in developing countries are actually growth enhancing. The size and timing of developing countries' emissions reductions is subject to considerable debate, often related to what constitutes a 'fair' division of responsibility between richer and poorer countries. The need for international support for many developing countries remains of high importance, *but this is true of BAU and low-carbon growth alike*. The issue is whether development ambitions are orientated towards a low-carbon pathway to lasting poverty eradication or a BAU pathway to poverty reduction that may be, at best, temporary.

World Bank Photo Collection: Stunted crops in the Kaffrine region of Senegal are the result of a lack of rainfall - Flickr

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