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Targeting Zero Zero

Achieving zero extreme poverty on the path to zero net emissions

Discussion Paper

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This discussion paper aims to stimulate debate on how to achieve Zero Zero – zero extreme poverty and zero net emissions. It has been prepared to frame the Development and Climate Days 2014 at COP20 in Lima, Peru. Hosted jointly by the Red Cross/Red Crescent Climate Centre, the International Institute for Environment and Development, the Overseas Development Institute and Climate Development Knowledge Network, the Development and Climate Days 2014 will bring together stakeholders engaged in climate talks and those developing the Sustainable Development Goals (SDGs). Feedback from the Development and Climate Days 2014 will inform a revised version of this discussion paper to be released in early 2015.

Abbreviations

ASEAN	Association of Southeast Asian Nations
BAU	Business as usual
CO_2e	Carbon dioxide equivalent
CPAN	Chronic Poverty Action Network
CRGE	Climate Resilient Green Economy
ETP	Energy Technology Perspectives
FAO	Food and Agriculture Organization
GDP	Gross Domestic Product
GHG	Greenhouse gas
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
LPG	Liquefied Petroleum Gas
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
SE4ALL	Sustainable Energy for All
SSA	Sub-Saharan Africa
UN	United Nations
UNDP	United Nations Development Programme
UNFCCC	United Nations Framework Convention on Climate Change
WEO	World Energy Outlook
WHO	World Health Organization
ºC	Degrees Celsius

I. Executive Summary

The eradication of extreme poverty is, perhaps, the minimum ethical floor for global development efforts. Progress over the past two decades has reduced extreme poverty from 43% to 17% for the population of the developing world, and macroeconomic projections suggest that 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 far beyond that deadline.

The eradication of extreme poverty by 2030 will be no great accomplishment if we are incapable of sustaining that achievement once reached. On current trends, the costs of climate change will fall hard on poor people, making it harder for those in extreme poverty to escape it, and threatening to drag the moderately poor (those living on $2 per day) into extreme poverty. Their continued vulnerability may require even greater ambition to ensure the resilience of poverty reductions. At the same time, curbing climate change to manageable impacts will require the global economy to produce zero net emissions by the end of the century. While this paper focuses on countries with large populations of extremely poor people, the global scale of this challenge means that every country – rich or poor – needs to pursue a trajectory of very low emissions.

The most credible scenarios for zero net emissions by 2100, including those upon which this paper relies for its calculations, foresee greenhouse gas (GHG) emissions peaking in all countries well in advance of 2050, and in most countries within a decade of 2030. Developed countries already need to see declines against current levels, but even low-income countries will need to peak within the timeframe of the zero extreme poverty goal. That peak will need to be somewhat lower than it would be under business as usual (BAU), and materially lower than, say, the emissions increases of countries that have industrialised rapidly in the past 30 years, such as China and some of the lower-middle income countries of South East Asia. Therefore, while the achievement of a zero net emissions goal looks toward the end of the century, the magnitude of the goal has very immediate and global implications for development.

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. The domestic actions of richer countries are critical and will influence the opportunities for sustaining zero extreme poverty in poorer countries, and these actions have rightly received much attention. This paper focuses instead on 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). There is strong evidence that a zero net-emissions pathway, both globally and in the poorest countries, is compatible with, and likely to be better at, achieving the moderate and sustained economic growth and addressing the inequality of growth – both prerequisites for the achievement of zero extreme poverty. This will, however, require significant improvements to institutional and technical capacity, as well as access to far larger amounts of investment than might otherwise be the case.

Pathways to zero extreme poverty

Various projections conclude that effective poverty eradication, with less than 3% of the global population living on $1.25 a day, is feasible by 2030. These projections, however, are narrow in their assumptions and their results depend upon overly optimistic projections of the scale of economic growth and its uniformity across sectors and countries. In addition, we face diminishing returns in terms of poverty reduction from growth, given the location and structure of the poverty that remains, with more poverty 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 likely to be more moderate and less effective in reducing extreme poverty in the coming decades than many projections suggest. Ensuring that we achieve the goal of zero extreme poverty by 2030 will, therefore, require a reorientation, and not simply a replication, of experience over the past two decades.

While moderate and sustained economic growth is necessary under nearly all poverty-eradication scenarios, it is also vital to reduce the inequality of the benefits of that growth. Poverty is reduced faster when poor people benefit more from growth and extreme poverty could be solved overnight if the inequality of wealth were addressed. Addressing growth and inequality together is far more likely to reduce poverty than a strategy that focuses on maximising growth alone. For example, the redistribution of wealth through cash transfers would, in theory, involve a relatively small fraction of the global economy, but such transfers can be quite costly at the local level, are politically unpalatable at scale, and have questionable sustainability if the inequality of growth has not been resolved. Robust poverty eradication must generate the circumstances in which the extreme poor can productively participate in the macroeconomy. Moderate, sustained, pro-poor growth – 'fair growth' – is likely to provide the best chance of reaching our collective goal of zero extreme poverty.

The impact of climate change on poverty

Climate change is already happening, with an estimated 0.85° Celsius rise in average global temperatures since pre-industrial times. Due to historical emissions, efforts to reach the goal of zero extreme poverty will be affected by climate change even if all GHG emissions were to be halted tomorrow. This means that investments in adaptation and resilience-building will be vital to defend poverty reduction gains from the climate change that the world is already locked into.

Although such investments are necessary for achieving and sustaining poverty reduction, this paper focuses not on their precise nature, but on pathways to zero net emissions that will minimise interference, or maximise synergies, with the goal of zero extreme poverty. To do so, the paper draws on two well-analysed emissions scenarios to generate preliminary estimates of the number of poor people directly affected by climate change.

In the first scenario, the world does nothing beyond its current policies and continues on a BAU emissions pathway towards 3.5°C by 2100. In the second scenario, large structural changes are made across a number of sectors to put the world on a trajectory to zero net emissions and a reasonable chance of staying within 2°C by 2100. Each will have consequences for eradicating poverty, given their influence on climate-change costs, benefits and their distribution.

BAU generates a strong 'headwind' against efforts to eradicate extreme poverty. This headwind comprises both the direct harm of climate change to poor people, and its indirect drag on the moderate and sustained economic growth necessary for poverty eradication. As temperatures increase, this headwind is getting stronger as it pulls in the non-linear impacts of climate change. The most direct negative impacts of climate change alone could affect hundreds of millions of poor people by 2030, whether those who are still living on less than $1.25 a day, or those who have only recently risen above that level.

When we focus on just three impact pathways, the productivity of primary sectors, climate extremes, and effects on childhood malnutrition and stunting, we find that hundreds of millions of people could be delayed in their escape from extreme poverty as a result of climate change. Table 1 outlines the impact pathways that are best understood. 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, higher food prices, and secondary impacts on child and female education, fertility and conflict. The impacts of climate change will also produce a macroeconomic drag, reducing the underlying economic growth that supports poverty eradication.

Table 1. Additional poor people impacted by climate change through decline in primary sector productivity, climate extremes and childhood malnutrition and stunting

Impact pathway	Description	Assumptions	Additional number of poor due to climate change
Decline in primary sector productivity	Estimated impacts of declines in agricultural and livestock productivity are applied to the likely size and distribution of the rural poor in 2030 (up to $2/day) in Sub-Saharan Africa and South Asia	Assumes productivity declines of 5-8% on average (and up to 20% in extreme) will affect only half of poor rural households.	250-500 million people in extreme poverty or "moderate" poverty (less than $2/day) exposed to multi-year, possibly decadal, set-backs to their efforts to exit extreme poverty
Climate extremes	Estimated impact of droughts on the livelihood of poor rural households by combining historic damage data, projections about 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.	An additional 100-150 million of the extreme or moderate rural poor pulled deeper into poverty each decade through exposure to extreme drought.
Child malnutrition and stunting	Estimated impact of climate change on the number of additional children suffering from malnourishment and stunting owing to 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 in a 2.0 degree rise.	About 120 million children are malnourished, and 30-40 million suffer stunting over the course of each decade.

Achieving zero extreme poverty on the path to zero net emissions

The message of these findings is that the pursuit of zero extreme poverty by major GHG emitters represents policy incoherence in the absence of immediate and ambitious efforts to move toward zero net emissions by the end of the century. This reaffirms the clear need for domestic mitigation by the world's largest emitters and for an international agreement that is capable of addressing the interdependency of effective climate action, but also positions poverty eradication as a catalyst for more ambitious action on climate change.

Growth-enhancing 'negative cost' opportunities for emission reductions are widespread in poorer countries, and initial evidence suggests that such opportunities could constitute the vast majority of their climate action by 2030, if optimal policies were implemented effectively (Figure 1). A pathway toward lower emissions than those associated historically with economic development, and consistent with a zero net emissions trajectory, is both feasible and affordable in countries fighting extreme poverty. This is especially true when co-benefits, such as reduced local pollution, are factored in.

While there is a lack of systematic evidence for the comprehensive assessment of mitigation potential and macroeconomic costs and benefits, early examples from the two regions with the greatest percentages of extreme poor – sub-Saharan Africa and South Asia – support this view. The best available evidence points to a positive net impact on economic growth in countries with many low-cost options, and a slower emissions reduction pathway (i.e. sub-Saharan Africa), and a small negative impact for countries with the biggest mitigation challenges (i.e. China). It also suggests a pattern of macroeconomic impact (low-cost measures and stimuli in the near term, with cost impacts in the medium term) that would, on average, be more conducive to the eradication of poverty by 2030. All regions, however, will require some actions that are potentially 'positive cost', and that could increase beyond 2030. It is critical, for example, to address the challenges of mitigation measures related to the rapid expansion of energy supply in large middle-income countries (MICs) like China, India and Indonesia. It is vital, therefore, to look more closely at the nature and potential impacts of these actions. In parallel with more global concerted action, the successful achievement of a Zero Zero pathway will require the careful management of these growth-reducing actions to ensure continued moderate and sustained economic growth in countries with significant levels of extreme poverty.

Climate action can have many direct benefits for poor people, whether improving their productivity, their access to public services, or the effectiveness with which their consumption is subsidised. If the goals of zero net emissions and zero extreme poverty are considered together, 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 that institutional and technical capacity, as well as financing, focus on programmes and investments for the poor. Table 2 sets out some key actions to mitigate the impact of climate change, their distributional impact on the extreme poor and additional policy considerations to ensure that these actions are pro-poor.

The exact pathway (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. Rather than enter into this debate, this paper attempts to understand the poverty eradication implications of emissions reduction pathways themselves. Regardless of the nature, scale, and even the moral imperative of foreign support, a series of domestic policy choices will determine whether these pathways are taken or not. For this reason, this paper focuses on defining the implications of those emissions pathways on poverty reduction. The issue of "fair distribution" and need for international support for many countries remains of high importance, but this is true of BAU and low-carbon growth alike, and whether or not the necessary actions are less

Figure 1. Growth-enhancing mitigation opportunities in countries or regions with extreme poverty

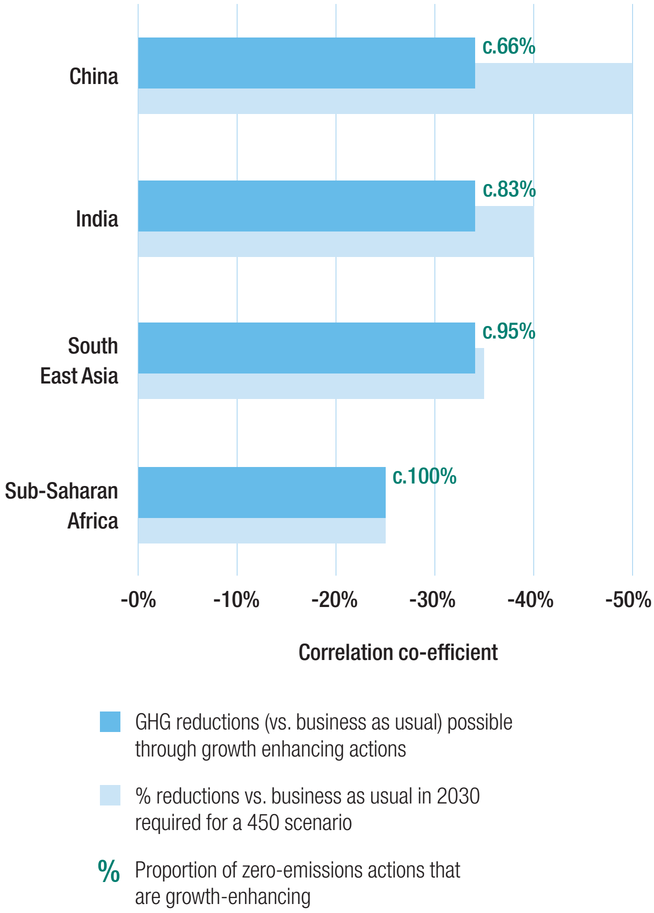


Table 2. Direct impact of key mitigation actions on the extreme poor

Mitigation action	Direct (distribution related) impact on 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.
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 needs to be 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.
Reduced subsidies for fossil fuels and fertilizer	– Better-targeted technical and cash transfers increase the income of those in extreme poverty.	– Depends on replacing regressive subsidies with better-targeted assistance.
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. – 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.

expensive than BAU development actions. 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.

Although climate action can reinforce poverty eradication efforts, 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. More practically, indirect redistribution, mobilising public resources to build human capital and facilitate productive employment—such as education and basic health services—are more about political will than about economic challenges, the need for growth, or GHG emissions. They also create the human capital and institutional capacity 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.

Transitioning to Zero Zero in energy systems, agriculture and human habitats

The achievement of zero net emissions will require a significant structural shift in major economic and social systems, and there will need to be major transitions in three areas in particular: energy, food and human habitat. While international discussions on low-carbon economies position sustainable energy access, productivity and urbanisation as central to transformation, the operationalisation of such transformations around a Zero Zero goal requires us to look beyond easy solutions.

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 that employ so many of the rural poor. Urbanisation holds the promise of more compact and more efficient human habitat, with better access to economic opportunity and public services: it can mean cities overwhelmed by human need and vulnerability, or it can mean cities capable of planning urban forms to better meet human needs in a changing climate. In each of these transitions, what we mean, what we prioritise and how, all have major implications for the rapid eradication of extreme poverty, for our emissions and climate trajectory and for other policy priorities.

Even though the two goals of zero extreme poverty and zero net emissions may align very readily in many cases, pursuing both simultaneously will not be easy. While we find fewer trade-offs between equitable growth and low-carbon growth, there are still politically tough choices about which development pathways we can rely upon to achieve lasting poverty reduction. A low-carbon growth scenario, in particular, requires a commitment to the complete transformation of three human systems; how we produce and consume energy, how we produce and consume food and how we arrange human habitat. In the aggregate, these transitions will require greater upfront investment, given the higher overall levels of human and physical capital required. In some cases, they will also come with the transaction costs of disrupting incumbent interests and managing such change. While detailed analyses of these transitions deserve a dedicated paper each, an analysis of the twin Zero Zero goals would be incomplete without acknowledging the challenges that these pose.

Stopping short of resolving these sometimes opposing challenges, this paper highlights the choices that sit beneath the ready answers and aims to reframe future policy-oriented research to handle these choices more effectively. Section II examines the Zero Zero challenge, before Sections III and IV examine, in turn, zero extreme poverty and the impact of climate change on poverty. Section V sets out ways in which the journey to zero extreme poverty could be combined with the journey towards zero net emissions. Section VI examines the unavoidable transitions that will need to be made in the energy sector, the agricultural sector and in human habitat. Finally, Section VII sets out two key conclusions: the achievement of Zero Zero will not be easy, but achieving Zero Zero is both possible and necessary.

This paper is very much a 'work in progress'. It is intended to inform and stimulate debate at the Development and Climate Days 2014 at COP20 in Lima, Peru, which will bring together stakeholders engaged in climate talks and those developing the Sustainable Development Goals (SDGs). Feedback from the Development and Climate Days 2014 will inform an updated version of this working paper to be released in early 2015.

II. The Zero Zero challenge

1. Getting to zero: within our reach

For the first time, it is possible to envisage the eradication of extreme poverty within a single generation. A world that Bono has called the 'zero zone' (Elliott, 2013), where less than 3% of the world's population live on less than $1.25 per day, is within our reach. Lifting today's one billion[1] people out of extreme poverty has become the first goal of 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), 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[2] – 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. Projections suggest that the 'effective eradication' of extreme poverty is possible by 2030 – at the end of the next round of global development goals. By most measures, 'effective eradication' means reaching a global rate of extreme poverty of 3% (Ravallion, 2013)[3], but this overlooks those who are hovering just above the poverty line, or 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, in itself, represents such a low level of consumption, that even when set alongside other laudable goals for human welfare, it seems to represent a minimum ethical floor for our development efforts.

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

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. Therefore, the way in which we reframe the goal of zero extreme poverty matters for the way in which we achieve it. Climate change increases the probability that those who emerge from extreme poverty will be at risk of falling back into extreme poverty. 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 that will be amplified by the greater frequency and magnitude of weather and climate hazards as driven by greenhouse gas (GHG) emissions (Gutierrez et al., 2014).

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).

Given that an increase above 2°C will make it hard to reach or maintain global poverty objectives, there would be little chance of reaching the zero zone in a greater-than-2°C world.

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.

1 Most recent estimates are for 2011 from PovcalNet.

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

3 Even under the most optimistic projections that show the goal of zero extreme poverty could be met by 2030, 200-300 million people remain in extreme poverty. In sub-Saharan Africa, this would still leave around 20% of the region's population living below $1.25 a day.

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

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. The world is already 0.85°C above pre-industrial levels and BAU scenarios estimate average warming of 1.5°C by 2030 (IPCC, 2014c). Even under the most optimistic and dramatic scenarios of GHG emissions reductions, the world is still locked into global warming caused by historical emissions. Because 'global mean temperature rise' represents an average, some areas will experience greater warming and its associated impacts. Then there are the impacts experienced in regions where communities, ecosystems and production systems 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, these climate-related factors have been omitted from projections of poverty eradication.

There is also a growing realisation that poverty goals will need to be more ambitious in the light of climate change, so that those making their way out of extreme poverty are less likely to fall back into it. 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 is already enduring a level of consumption that is far too low to be capable of such resilience. This means that we need to be even more ambitious about our poverty goals in the context of climate change, 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 An income-based resilience line can be a useful foundation for the re-assessment of our extreme poverty goal. While a precise dollar amount for resilience is likely to be far higher than the amount for poverty, this paper uses $2 a day 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).

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.

3. Pathways to Zero Zero

What options already exist to achieve the goal of zero extreme poverty by 2030? To move through that goal to ensure that poor people do not fall back into poverty? To maintain poverty reductions by reaching zero net emissions by 2100? This working 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 focusses on the scope for synergy between poverty reduction and low emissions pathways as well as on domestic development policy choices, while noting that the domestic actions of richer countries remains critical and influential on the opportunities for sustaining zero extreme poverty. It aims to pave the way for a more comprehensive discussion about the more ambitious pathway that is needed to achieve and maintain the eradication of poverty in the face of a changing climate. It intends to provoke and stimulate debate on how possibility can become reality to ensure that the eradication of poverty does not slip beyond our reach.

Section III 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 then identifies likely elements of a sustained scenario of zero extreme poverty, concluding that moderate and sustained economic growth that is accompanied by reductions in the inequality of that growth is the most realistic pathway toward the goal of zero extreme poverty.

Section IV 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. 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 who are likely to be impacted directly by climate change. It also considers how adaptation can help to 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 V explores the evidence that pathways towards zero net emissions are consistent with poverty eradication goals. It finds a substantial body of early evidence showing that there is significant scope for both growth-enhancing and poverty-reducing low-carbon development choices, and 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 that moves 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 that are necessary for zero extreme poverty, and certainly far more compatible with sustained poverty eradication than BAU.

Section VI dives deeper into three major transitions that need to take place to move toward zero net emissions, each one of which will have implications for the goal of zero extreme poverty. Looking at energy, agriculture and human habitat in turn, this section considers the relationship between the transition and poverty goals, the opportunities for synergy between the goals and the challenges that meeting these goals pose to that particular sector.

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

III. 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), 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), and is the subject of a growing activist campaign (Global Poverty Project, 2013).

The global progress that has been 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. However this progress was not equitable. Extreme poverty has decreased most dramatically in East Asia, especially China, but as of 2011, over 80% of the world's poorest people are concentrated in sub-Saharan Africa and South Asia (PovCal, 2014).

Based on these recent trends, prominent development economists such as Martin Ravallion and Laurence Chandy have projected that 'effective' poverty eradication is possible by 2030. These projections are, by nature, narrow in their assumptions. They tend to focus on extreme income poverty (measured as less than $1.25 per day) rather than

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.

a broader or multidimensional measure of poverty, assume uninterrupted decades of high growth rates and assume 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 a 'fool's errand' (Chandy et al., 2013). Nevertheless, these projections have helped to galvanise international development and have focused attention on the fact that the eradication of extreme poverty is not a fool's errand by any means. Most projections, under narrow and optimistic assumptions, show that it is possible to eradicate poverty effectively by 2030. Figure 2 shows historic poverty reductions (in blue) trending down, illustrating the significant poverty reductions over the past two decades. The projections by the major economists on poverty reduction are plotted against this trend, clustering in the bottom right corner and showing a high level of consistency.

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

Economic growth is required under most projections to reach effective extreme poverty eradication by 2030. This is true of both projections that assume high growth and that hold other variables constant (like those discussed above), and projections that consider possible changes to other factors, such as inequality (like those of 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

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 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.

Therefore, while poverty assessed in monetary terms links well-being to command over commodities, multidimensional poverty includes broader types of consumption; for example, if people are in poor health, feel powerless or lack political freedoms .

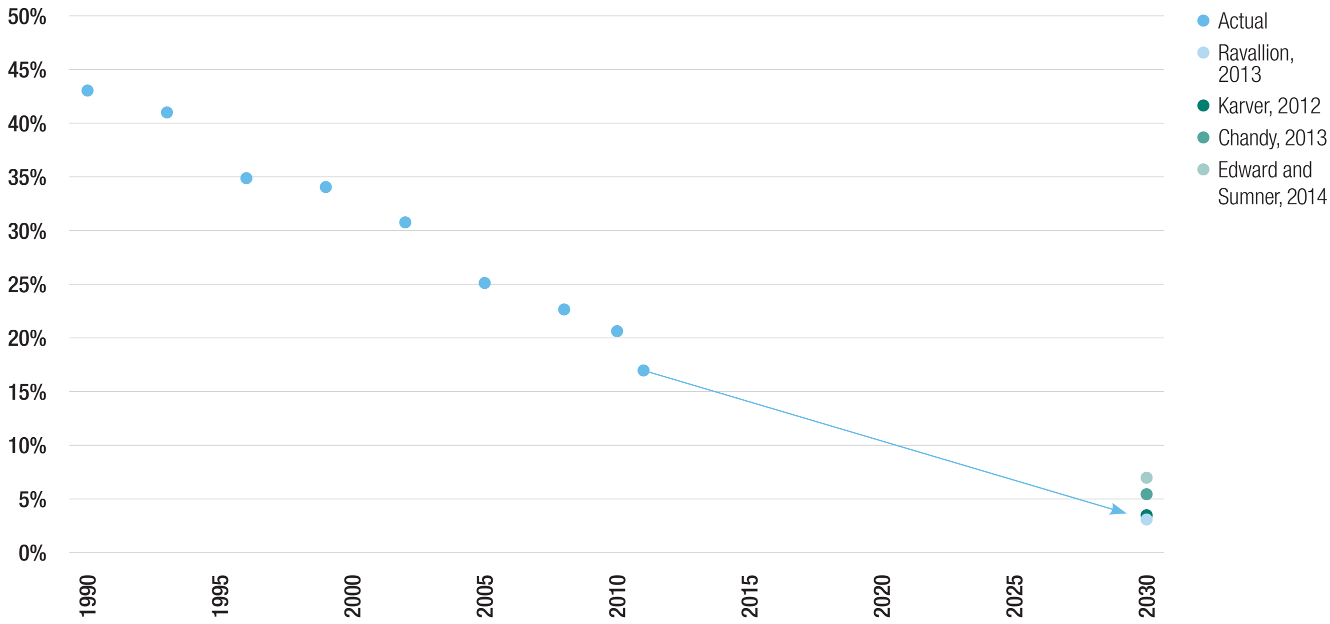
The Millennium Development Goals (MDGs) and the 2001 World Development Report highlighted the need for broader poverty measures; the latter also expanded the notion of poverty to include vulnerability and exposure to risk. The Human Development Index (HDI), measuring progress in health, knowledge and 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. Understandably, countries have increasingly used household survey tools, such as demographic and health surveys, to construct multidimensional poverty measures through which to measure progress.

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. The MPI gives both the headcount of multidimensional poverty and its intensity (as the amount of deprivations experienced at the same time), thus scoring people as 'near multidimensional poverty', 'multidimensionally poor' or in 'severe poverty'. 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 is can be measured, there remains academic debate on the approach. Challenges remain in the choice of dimensions, the method to aggregate multiple dimensions, as well as in distinguishing the cut-off point between the poor and non-poor in each dimension, and how to weight dimensions to establish a single metric . Different dimensions may also be relevant in different countries that makes comparison complex. More fundamentally, the lack of correlation between dimensions of well-being has challenged the focus on a single indicator and there is debate on the merit of a basic needs approach as opposed to a functioning capabilities approach .

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 2. Projections of extreme poverty headcount rate in 2030



through domestic policy choices, and make it more difficult – politically and practically – for developed countries to support such activities.

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 has 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 well-being 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 $1.25 a day poverty has declined over the past two decades, the share of people 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 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).

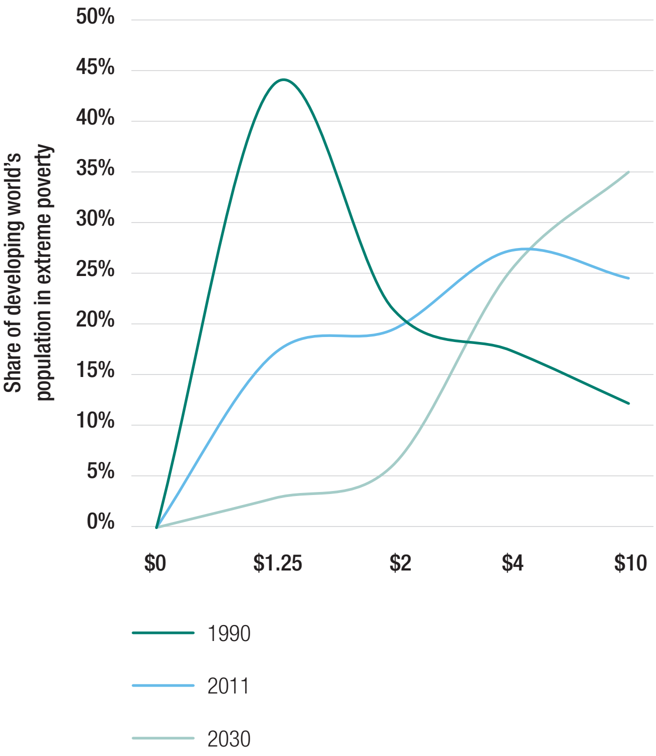
People living just above the poverty line are very vulnerable to falling below that line (Hulme et al., 2001; Yemtsov, 2013; Suryahadi and Sumarto, 2003; World Bank, 2014b; Calvo and Dercon, 2012; Samman, 2013; Pritchett et al., 2000; Christiaensen and Subbarao, 2005; Chaudhuri, 2003; de la Fuente et 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 IV.

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 and projecting them decades into the future paints an overly optimistic view of extreme poverty in 2030. Such projections could be derailed if such growth rates are not sustained. Lower than projected growth rates over the next 15 years could leave around 10% of the world's

Figure 3. Consumption distribution



Source: PovCal, 2014

population in extreme poverty in 2030 (Ravallion, 2013; Chandy et al., 2013; Edward and Sumner, 2014). This equates to an extra half a billion people in extreme poverty in 2030 and would push 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, 2014d; 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, 2014a). According to the Bank's calculations, a global extreme poverty rate of 7% or higher in 2030 is likely, based upon more realistic growth projections that hold everything else constant (World Bank, 2014a).

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[4] and poor (PovCal, 2014). The strength of the relationship between growth for the poor and for the non-poor in sub-Saharan Africa has been lower than in either East or South Asia (Figure 4) (PovCal, 2014). Chandy et al. (2013) maintain that growth in sub-Saharan Africa seems to have had less of a poverty reducing effect than in India or China. This has significant implications when considering the role of growth in being able to lift people out of poverty in the future.

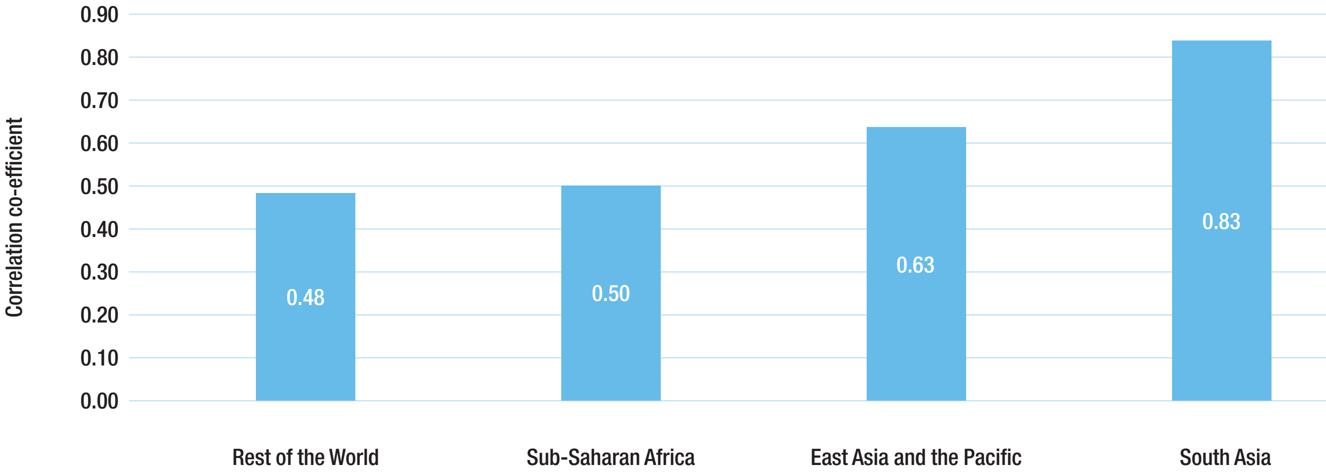
Simply projecting recent growth trends forward over long time horizons does not factor in which sectors have been driving growth and is a poor foundation for expectations on poverty reduction. Prolonged periods of growth over recent decades tend to have been driven by increased agricultural productivity that has allowed surplus labour to shift towards the manufacturing sector, as in China (Knight, 2007; Islam and Yokota, 2008). However growth in many other developing countries over the past decade has been driven by 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).

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, as 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 that they rise to different heights in different places. Inequality could also hamper poverty eradication: reductions in both inequality and poverty can be seen as essentially political processes, and policies that favour extremely poor people will compete with policies in the interest of other, certainly wealthier and often more influential stakeholders (Geels, 2014), and greater inequality can make the interests of different segments of the population all the more divergent.

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

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



Source: PovCal, 2014

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

A realistic pathway to poverty eradication requires a focus on maintaining moderate, sustained 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, as long as a larger share of growth accrues to those in extreme poverty.

Projections based on historical trends estimate that the extreme poverty rate in 2030 could be up to three times higher between the projections that are based on more and on less equal distributions of growth. Chandy et al. (2013) show that reducing inequality can have just as large an impact on poverty reduction as growth. Poverty reduction depends on the 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 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, while the consumption of non-poor people in India grew twice as fast as it did in Bangladesh (PovCal, 2014).

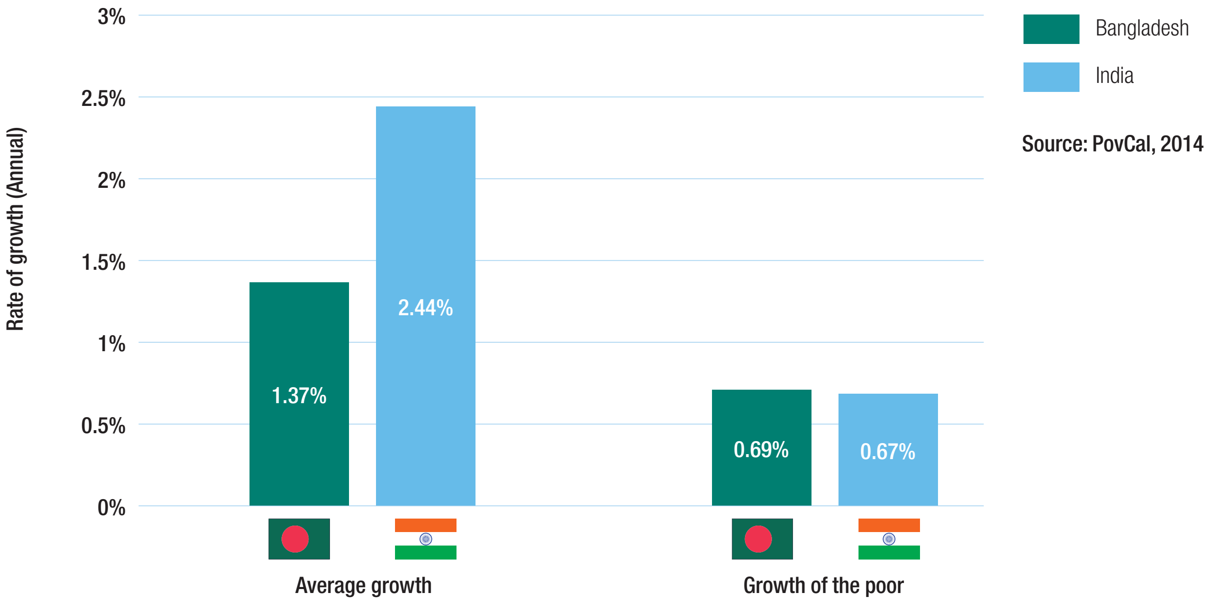
More nuanced quantitative analysis of growth for the poorest of the poor reinforces the need to address inequality. Woodward (2013) attempts to quantify the time it would take to effectively eradicate poverty without directly addressing inequality. He makes optimistic assumptions similar to the projections above and examines how growth will impact those living on the lowest incomes in the world, which he assumes are half the mean of the incomes in the bottom decile. It would take over a century for these people to escape from extreme poverty using historical growth rates (from 1993-2008), holding inequality constant and excluding China from the analysis (given its exceptionally high growth rates across deciles). This would entail the world economy growing by 1500% in 100 years and average global incomes rising above $100,000 (2005 PPP) per person, which would have radical implications for carbon emissions. 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 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, 2014a). World Bank Chief Economist Kaushik Basu maintains that addressing inequalities head on will be crucial and that 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 1% – 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, 2014d; PovCal, 2014; Woodward, 2013).

Figure 5. Comparison of India and Bangladesh



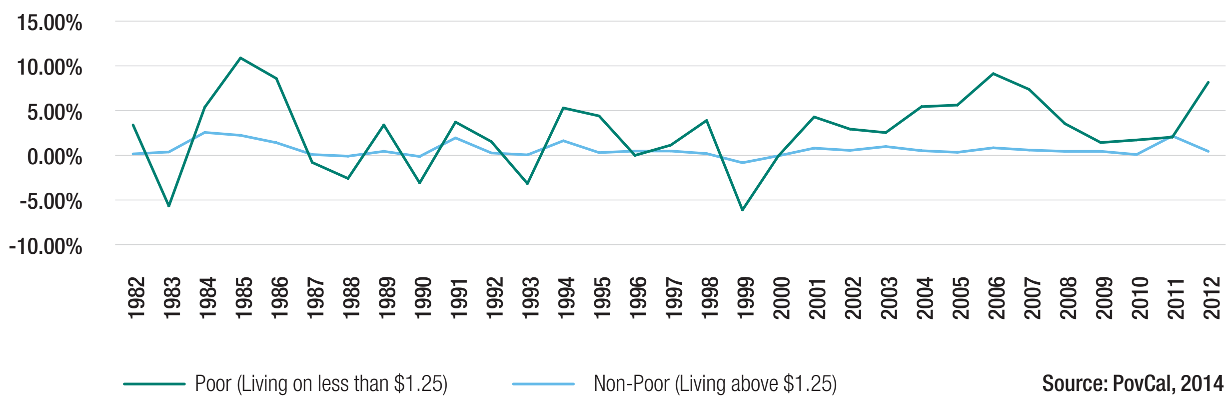
Source: PovCal, 2014

While this thought experiment is difficult to envisage in practice, it highlights the way in which growth that directly benefits those in extreme poverty could be very effective in eradicating poverty even in a context of reduced overall growth rates.

The fact is, however, that, on average, poor people have not 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 at less than half a percentage point.[5] This growth path corresponds to increasing levels of inequality.

Broadly speaking, more equal distribution of growth, and greater distribution to poor people in particular, can be achieved through redistribution of resources so that the poor can make a larger contribution to, and benefit more from, growth. Redistribution occurs through the mobilisation of public revenues that enable poor people to consume more goods and services. In the simplest terms this can include 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. This is a pre-condition for more equitable growth, as it enhances the economic productivity of poor people

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



Source: PovCal, 2014

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

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. The perfectly targeted redistribution of existing wealth could increase the consumption of those in extreme poverty to above $1.25 a day, with little or no effect 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 had shrunk to less than 1/2000 of global GDP by 2011 (World Bank, 2014d; 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. The actual cost required to target adequate cash transfers towards those in extreme poverty is likely to be well in excess of the size of the poverty gap. A cash transfer would only help to raise current consumption, and regular payments would be needed to ensure that future consumption remains above $1.25 a day. Ongoing cash transfers across 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) attempts to determine the affordability of basic cash transfers and shows that it is unreasonable to expect that even basic cash transfers are affordable until a country has a high enough income per person (in the order of $2,000-4,000, 2005 PPP). Most LDCs would need far greater growth to raise enough domestic resources to redistribute 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 it cannot, therefore, be seen as a substitute for growth.

Nevertheless, we should note 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 be essential in the 'last mile' of the journey from 'effective' zero extreme poverty toward truly zero extreme poverty. And it is important to recognise that cash (or consumption-based) redistribution will also be needed to permanently eliminate extreme poverty among some disadvantaged groups in society, such as those who have disabilities, who are marginalised and who are older. These groups are less likely to be able to contribute directly to the economy and without redistribution of wealth could remain in extreme poverty for many decades to come. This was one of the reasons for the introduction and continuation of social transfers in most high-income and some middle-income countries.

b. Broader forms of redistribution enable equitable growth

Direct cash transfers have their place in poverty reduction, but broader redistributive 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). Nevertheless, 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, but also by creating the circumstances in which they can benefit themselves as participants in the economy.

Without judging the relative importance of specific aspects of this shift, or the relative effectiveness of precise measures, we summarise five key elements that are seen as critical to more equitable growth, drawing on the work of the Chronic Poverty Advisory Network that 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 in 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, i.e. sub-Saharan Africa and South Asia (Montenegro and Patrinos, 2013). Education expands human capital productivity, and its broad availability will, therefore, have an impact on the distribution of growth.

Asset accumulation

Second, more equitable growth involves the accumulation by poor people of assets, such as land and physical capital that improves their income, and that 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). Finally, the accumulation of such assets both facilitates and incentivises the accumulation of human capital (Vandemoortele et al., 2013).

Improving pro-poor infrastructure and services

Third, more equitable growth involves public services and infrastructure designed specifically to service poor people, including energy, water and transport (World Bank, 2014c; Practical Action, 2014). People often stay in poverty because they are unable to exploit the returns to their own human capital and assets because they lack infrastructure and services that are 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). Here again, a virtuous cycle exists between one form of pro-poor redistribution and others.

Increasing employment opportunities

Fourth, more equitable growth also entails 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, found that it was finding jobs and starting new businesses that lifted them 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 sectors (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. In addition, this involves developing fundamental structures to ensure decent conditions for workers (Aidt and Tzannatos, 2002). Employment guarantee schemes by governments can also contribute, such as the Expanded Public Works Programme in South Africa, the Productive Safety Net Programme in Ethiopia, and the Mahatma Gandhi National Rural Employment Guarantee Act in India (Shepherd et al., 2014). 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 entails changes to dimensions of life that may be affected by (and affect) all of the above, but that cannot 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 their ethnicity, caste or race, are more likely to be in – and stay in – poverty (Baulch, 2011).

Many of these five elements 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, and so on. Ultimately, however, the ability of growth to serve extremely poor people will depend not only on economic growth, or on the public intervention to help poor people enabled by growth, but whether that public intervention is designed to make poor people themselves the engine of growth.

IV. The impact of climate change on extreme poverty

The previous section laid out credible but challenging scenarios for the eradication of poverty by and beyond 2030. Success will depend on sustained economic growth, but also on growth that is more equitable and that reduces the likelihood of falling back into poverty. Critically, the achievement of this goal will depend on whether and how the world takes action to mitigate and adapt to climate change. However, the relationship between 'zero extreme poverty' and 'zero net emissions' has yet to be considered comprehensively. This section lays out two scenarios: uncurbed climate change and a potential pathway towards zero net emissions. It examines the key implications for a goal of zero extreme poverty, given what we know about the impacts of climate change and our ability to adapt to them.

1. Pathways to a significant risk of catastrophic climate change

The effects of climate change are already clear. 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).[6] The future physical geographic distribution of climate-change impacts and resultant economic impacts are, however, uncertain. Climate and natural-systems models can help to predict 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;[7] while macroeconomic and sector models can help predict future economic impact. Together these allow future impacts to be assessed through scenarios.

As noted, this paper uses of 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 3, overleaf).

A 1.5-2.5° 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). A *very high risk* of such catastrophic outcomes is experienced at 3.5° (IPCC, 2014g). 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, even by 2050, and the second representing a relatively safe bet.[8]

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%[9] decrease against current emissions by 2050. The two scenarios imply different policy actions, which drive different patterns of economic activity. These crucial differences have consequences for the eradication of poverty as they influence costs, benefits, and their distribution.

Image: Surtrek Tour Operator/Flickr

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

7 '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 heat waves, droughts, floods, sea level rise, hurricanes, storm surges, coral reef extinction, ocean hypoxic zones, forest dieback, etc. 'Damages' refers to the 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, etc.

8 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.

9 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.

Table 3. Business as usual and zero net emission scenarios based on the most robust and widely-referenced sources for these scenarios of the IPCC and the IEA.

Scenario	Linkages with existing scenarios	Expected temperature increase versus pre-industrial levels	
		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.[10]	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°)

* 90% probability range shown within brackets.

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

a. Climate change creates a significant drag on poverty eradication

Climate change in a BAU scenario creates a strong and costly headwind that pushes against efforts to eradicate poverty. The poor tend to be more exposed to climate-impacted sectors as well as to be more vulnerable to impacts, where vulnerability refers to the severity of the change and the ability to respond to it (Barr et al., 2010). 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 a day, high levels of vulnerability remain. This represents an income level 60% higher than the extreme poverty line, but vulnerability persists because of a combination of factors, including the lack of household assets, credit, insurance, a social safety net and an adaptable skills set. A $2 a day line may be a very conservative proxy for a resilience line, but we use it in this paper to show the raised ambition that will be needed to meet even this modest 'resilience line'. This higher threshold for vulnerability means that we must consider the impacts of climate change not only on those currently living in extreme poverty (1 billion today), but also the larger population of poor people who are at risk of falling into extreme poverty. This equates to over 2 billion living on less than $2 today and even under the optimistic growth scenarios (that hold inequality constant), projections show almost one billion people below $2 by 2030.

b. Climate change has an impact on most aspects of life for poor people

A number of climate impacts that are likely between 2030 and 2050 – the period of greatest relevance to the achievement of zero extreme poverty – are of direct relevance to poor people (IPCC, 2014e) and their potential size and scale can be illustrated through three impact pathways. These are plausible mechanisms by which known environmental effects of climate change could hit the poorest people. For each impact pathway, an order of magnitude estimate is calculated for the number of poor people made vulnerable by climate change and that, therefore, may jeopardise the maintenance of zero extreme poverty from 2030 onward. These impact pathways are not comprehensive: other impacts could include higher incidence of airborne diseases, higher adult malnutrition, higher food prices and secondary impacts on child and female education, fertility, and violence. However, they illustrate the potential impact on poverty of some of the larger, and more robustly estimated climate damages:

- *Impact Pathway 1 - Declines in primary sector productivity keep hundreds of millions in poverty.* 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. The proportion of rural households in poverty varies from about 10% in China to over 50% in much of Africa, with a total of about 700 million rural people in extreme poverty, and perhaps double this number of people living on less than $2 a day.[11]

10 These range from 720 to 1330 ppm CO2e by 2100.

11 According to the World Bank's 'World DataBank', poverty rates (according to national poverty lines) are about 10% in China, 15-25% in Southeast Asia, 25-35% in South Asia, and 35-70% in Africa.

The rural poor will 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, of course, in terms of exposure to risk, dependency on primary sector incomes, current land productivity and access to productivity-enhancing techniques, for example. 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) as a result of climate change could, however, have a major impact on their well-being.

Median impacts on crop and livestock yields at 2°C of average warming have been estimated at a 5-8% reduction.[12] Even those populations experiencing strong growth in agricultural productivity of around 1-2% yield growth per year could experience multi-year set-backs in their income growth and in their exit from poverty.[13] Even if agricultural households have non-farm income sources, the underlying drag on the rural economy could also impact non-farm activities. In comparison, those experiencing relatively slow productivity growth – generally the poorer and most vulnerable – of around 0.5-1.0% per year, will be subject to larger climate impacts, such as a 20% reduction in yields[14] under the same level of warming (Fuglie and Rada, 2013). With no alternative sources of income, this could set back their income growth for a decade or more.[15]

Focusing on the two largest populations of rural poor, studies in sub-Saharan Africa and South Asia have shown the negative impacts of 1.5°C to 2°C warming (by 2030-2050) that would affect large parts of these sub-continents. Although subject to a high degree of uncertainty, even a conservative assumption that only half of poor rural houses feel the impact would mean that 250-500 million people in extreme poverty or 'moderate' poverty (less than $2 a day) will be exposed to set backs to their efforts to escape from poverty for years, and possibly decades.

- *Impact Pathway 2 - More frequent climate extremes drag hundreds of millions of poor rural people deeper into poverty.*

There is strong historical experience of extreme weather events having a ruinous and long-lasting impact on the economic well-being of the rural poor (Shepherd, et al., 2013; World Bank, 2013c). Therefore, even households showing relatively strong improvements in income and well-being over many years might see themselves pulled back into poverty by a single extreme event.

While climate extremes (e.g. tropical storms, floods, droughts and heatwaves) are difficult to predict with any certainty, there is strong evidence that they will increase across many regions. Unusual and unprecedented heat extremes that are rare today will occur in 20-70% of land areas in key planting seasons (World Bank, 2013c). Studies also show an increased failure rate of the primary growing season from 1 in 5 years today, to 1 in 4 years, and then 1 in 3 years for warming of 1.5°C to 2°C for rain-fed systems across large portions of Africa (Jones and Thornton, 2009). There are also likely to be large increases in the incidence of drought (Dai, 2010; 2013).

Focusing on droughts, data show that from 1980 to 2013 large-scale droughts (by definition affecting millions of people) occurred about every year or two, and mega-droughts (with tens of millions affected) occurred every 3-4 years in each major region (CRED, 2014). Droughts and their damages, therefore, have already affected hundreds of millions of poor people in rural areas over the past three decades. Making a plausible assumption that the frequency of such events might double from that period to the period of 2030 to 2050 as we approach 2°C, and applying it to the expected populations of rural poor in 2030 (up to $2 a day), we find that such events could pull an additional 100-150 million of extremely or moderately poor people in rural areas back into poverty each decade. 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.[16]

- *Impact Pathway 3 - Climate damages directly increase child malnutrition and stunting, reducing the underlying capacity of tens of millions of poor people to escape from poverty.*

12 These are median impacts as estimated in the World Bank (2013) Turn Down the Heat, citing Roudier et al. (2011) and Knox et al., (2012) for crop yield estimates; 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.

13 With underlying productivity growth of 1%, a 5-8% productivity loss would take 5-8 years to recoup. At 2% underlying growth, this would be 2.5-4 years.

14 See a variety of studies cited in World Bank (2013) Turn Down the Heat showing potential impacts in particular regions or for particular crops and livestock of c.20% or more for warming roughly in the 1.5°C to 2.0°C range considered.

15 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%.

16 Estimates of historic damages for floods are quite similar to those for droughts, although more frequent in Asia than in 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.

One of the most serious underlying drivers of intergenerational poverty is malnutrition and stunting; which if suffered in childhood has long-term effects on adult success (Banerjee and Duflo, 2011). Recent studies have estimated the potential impacts of 2°C warming (by 2050) on malnourishment and stunting to be around a 100% and 20-40% increase respectively, as compared to a no climate change scenario (Lloyd et al., 2011). Such an increase means that roughly 15-24% of children will be malnourished and 4-8% of children will be stunted who wouldn't be otherwise, which translates into around 120 million children being malnourished and 30-40 million being stunted each year over the course of each decade in sub-Saharan Africa and South Asia as global temperatures warm by 2°C. These are children who are likely to have lower education achievement and lower economic status in adulthood (Victora et al., 2008), with an impact on their own personal income and a cumulative impact on their countries' levels of poverty and economic growth.

While these three 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 well-being of the urban poor. Indirect impacts on health and food prices, for example, could also have significant affects. However, studies have not yet provided a comprehensive picture from which the adverse impact on a zero extreme poverty goal can be estimated. Relative to the impact on the rural poor, the impact on the urban poor appears to focus in a specific sub-set of areas. This is especially true in coastal cities as the risks they face will increase as sea-levels rise.

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

Although the world is likely to be significantly wealthier by the second half of this century, approaching 3.5°C could make it almost impossible to eradicate poverty. Broad assessments of the potential catastrophic impacts at these levels of climate change include, for example:

- a 40% decrease in precipitation in southern Africa, with adverse consequences for predominantly rain-fed crop and livestock production
- a rise of 100 cm in sea-levels by the 2090s that would increase the share of the population at risk of flooding in Guinea-Bissau and Mozambique to around 15% by 2100 (compared to around 10% in projections without sea-level rise)
- an increase of up to one third in the frequency and wind-speed of the most intense storms and tropical-cyclone-related rainfall in South East Asia and the Philippines, indicating a higher level of flood risk in low lying and coastal regions (World Bank, 2013d).

Although the number of extremely poor people should be very small by 2050, the extent of these catastrophic impacts suggests that the vulnerability line could become significantly higher than the $2 a day conservatively assumed here. 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 as a given the continued historical trends in growth. This may be overly optimistic (see Section III), so even with strong baseline trends, sustained poverty eradication beyond 2030 is not likely to be impossible 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 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 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. In 2007, the UNFCCC estimated investment and financial flows for adaptation required for five key sectors in 2030 would be in the range of $28-67 billion per year in developing countries (UNFCCC Secretariat, 2007).[17] This is largely in line with earlier World Bank estimates of adaptation costs in developing countries of $10-40 billion in 2030 (World Bank Development Committee, 2006), constituting a 'climate mark-up' on climate-sensitive investment. Assuming that countries would adapt to the level at which they would enjoy the same level of welfare as a world without climate change, a more recent World Bank study placed the costs of adaptation in developing

17 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.

countries at $70 billion to over $100 billion by 2050 in a 2°C world (World Bank, 2010).[18] These costs increase dramatically as temperatures increase. An evaluation of the adaptation gap in Africa found that present and committed climate change will cost $7-15 billion a year by 2020. While 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 (Schaeffer et al., 2013).

Costs estimates are likely to be conservative, often as a result of the uncertainty and diversity of climate impacts, the multitude of possible adaptation options, and data limitations in a number of sectors (health impacts are often estimated through just a sub-set of key impacts – especially diarrhoeal disease, malaria and malnutrition – and non-market impacts on ecosystems are often omitted) (Parry et al., 2009; IPCC, 2014f). They also often omit 'softer' adaptation measures such as behavioural and policy measures, focusing instead on 'hard' adaptation measures that are easier to cost (OECD, 2008). The effective implementation of hard adaptation measures, however, may rely on such investments in institutional capacity and technical skills and the IPCC and others have proposed that soft adaptation may, in some instances, be the best use of funds (Fankhauser and Burton, 2011; IPCC, 2014f). Many countries with high levels of extreme poverty lack the requisite institutional capacity and technical skills for effective implementation, and the efficacy of adaptation is likely to be compromised without significant national and international support to build such capabilities.

The efficacy of adaptation measures is largely untested against the climate extremes expected at 3.5°C or more. 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 such damages unavoidable (Parry et al., 2009) and 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).[19] 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 off-set these negative impacts in the long-term.

While taking into account the uncertainty and incompleteness of current evidence, the best available assessments allow us to give an indicative picture of the likely costs of climate change to efforts to eradicate extreme poverty. Taking the estimates of adaptation costs in 2030 from the studies cited above, and comparing them to projected GDP in 2030, 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, with relatively greater costs in the poorer regions like sub-Saharan Africa. Such investments are bound to crowd-out other productive investment opportunities and 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.

18 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 A2 SRES emissions scenario with a relatively dry scenario from the CCSM3 climate model of the Commonwealth Scientific and Industrial Research Organisation (CSIRO) and a relatively wet scenario from the Mk3.0 climate model of the National Centre for Atmospheric Research (NCAR).

19 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.

V. 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, with the mostly widely accepted scenarios exhibiting fairly similar characteristics, summarised in Box 3 below, and all of them are broadly in line with the scenarios that form the basis of this analysis. They provide an initial assessment of the costs and benefits of a pathway towards zero net emissions, as well as being the most widely built-upon scenarios for more detailed efforts to assess the costs and benefits of climate action.[20]

Different scenarios present a range of benefits and costs related to the achievement of zero net emissions. This depends, to some extent, on the varying assumptions about consumer and company behaviour (demand), and about the availability and cost of key technologies. It also depends on the thoroughness of the assessment in terms of understanding existing market imperfections and incorporating a full set of potential economic impacts. Leading assessments are now incorporating transformational – as well as incremental – shifts in major economic systems, and a more explicit role for innovation. They are also incorporating co-benefits, such as reduced price distortions (e.g. from fossil-fuel subsidies), reduced local pollution (and improved health), and improved eco-systems services (e.g. water filtration). The resulting scenarios highlight the importance of specific structural shifts in achieving an efficient zero-carbon transition, especially in urban development, agriculture and land-use, and in energy, with underlying support from financial and innovation systems.[21]

Box 3. 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 (negative) cost mitigation actions for early uptake. Therefore, a large proportion of climate action by 2030 is expected to increase overall economic growth, and 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 relative high levels of emissions reductions.
- They assume that 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.

20 Such studies are critical to the analysis here, and include an enormous number of intervention-specific or locally-specific studies, as well as broad assessments conducted by entities like the OECD, the World Bank and the New Climate Economy Initiative.

21 Although results are often cited from more limited assessments (looking at narrow, incremental changes to a close-to-optimal BAU), this paper focuses on more robust scenarios that incorporate a broader set of market imperfections, transformational shifts, and potential co-benefits. Given their limitations and inflexibility, the incremental scenarios often showed unrealistically high costs.

Many, if not most, actions required for GHG mitigation by 2030 provide more quantifiable economic benefits than costs. Ignoring studies with obvious and severe shortcomings, assessments of the 'negative cost' actions that both reduce emissions and improve growth vary from about 50% to 90% of the GHG mitigation required globally by 2035 according to a 450 ppm – or zero net emissions – pathway. Similarly, assessments of the aggregate economic impact vary from about just over 1% to just under 3% of global GDP by 2050 (NCE, 2014; IPCC, 2014c).[22]

The modest economic cost indicated by these most recent assessments underscores 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. Given the moderate cost of action, and the negative impact and cost of BAU, 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. It would be, in turn, policy incoherent for high-emitting economies to prioritise the eradication of extreme poverty eradication (either globally or domestically), while failing to reign in emissions in line with a zero net emission trajectory.

a. A zero net emissions pathway need not harm economic growth

Unfortunately, there are not many specific assessments of a zero-emissions pathway for countries that suffer from the highest levels of extreme poverty, and there are no assessments that have looked comprehensively at the implications of climate action by poor countries on their ability to eradicate poverty alleviation. Nevertheless, by looking at assessments for key countries/regions with large amounts of extreme poverty (Africa, South Asia, and Southeast Asia), and aggregating existing information from more specific studies, we come to some initial conclusions about the possible impact of a zero net emissions pathway on the goal of eradicating extreme poverty by 2030, and the impact of that eradication on net emissions.

Positive impact is possible, but it requires political will, capacity and resources. A closer examination of the pathway towards zero net emissions for major countries or regions with significant levels of extreme poverty shows that such a pathway would be unlikely to harm economic growth through 2030, and would, indeed, be more likely to have a positive impact, especially for the poorest countries. This pathway would, however, require decision-makers to have the foresight, capacity and resources to make the right choices.

The growth benefits of a zero-emissions pathway for poorer countries is driven by two key factors. First, these countries have a large number of opportunities to reduce emissions at negative cost, and can, therefore, boost growth. Second, these countries are expected to reduce their emissions more gradually and to receive international transfers, although the latter depends on uncertain commitments by richer countries.

Work to date points to a significant number of growth-enhancing mitigation opportunities in LDCs. While there is insufficient analysis to assess the mitigation potential and macroeconomic cost-benefits specific to these countries systematically and comprehensively, early examples support this view. To illustrate this, we look at examples from the two regions with the greatest percentage of the remaining extreme poor: sub-Saharan Africa and South Asia. We also highlight some significant progress in the past few years in our understanding of mitigation options and the macroeconomic impacts (Table 4, overleaf).

A number of country-level studies have conducted relatively restricted assessments based largely on incremental improvements to a high-carbon BAU pathways using available technologies. These studies have shown significant growth-enhancing opportunities, but with considerable variation in results because of the limits of their methodologies. These studies have tended to find that 15-30% of emission reductions versus BAU were negative-cost (i.e. growth enhancing), only finding negative GDP impacts for activities reducing emission between 30-50% versus BAU.

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)[23] at negative cost, creating significant opportunities across sectors, including agriculture and forestry (MoFED, 2011). The study found that emissions to 2030 could be reduced by a further 25% at relatively low cost (<€10 per tonne). In India, a McKinsey study of mitigation options found that India's emissions to 2030 could be reduced by about 15% (vs. BAU) with actions involving a negative cost, and by about 10% more at a cost of <€10 per tonne. It found very few

22 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), while many macroeconomic studies tend to look at the 2050 timeframe, when long-term equilibrium can be estimated.

23 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.

Table 4. Understanding mitigation options and macroeconomic impacts in key countries

Country	Methodology	% GHG emissions reductions at negative cost (vs. business as usual)	GDP Impact	Notes
Ethiopia(CRGE)	MACC[24] - incremental improvements to BAU	33% (by 2030)	N/A	Further 25% reduction possible at <€10 per tonne
India	MACC - incremental improvements to BAU	15% (by 2030)	N/A	Further c.10% reduction possible at <€10 per tonne
India	Energy system and macro-economic model. Incremental technologies and no incorporation of co-benefits	N/A	-3.3% (total impact)	Looked at total impact of a 30% reduction in emissions vs. BAU.
Nigeria	Variety of sector models for four detailed sectors analyses	31% (by 2035)	+2%	Further 19% reduction possible with GDP impact of -1% (full net impact +1%)
Africa	IEA Efficient World Scenario (Energy system model) and OECD Macro modelling	c.25% by 2035	+3.9%	Household consumption benefits were 40-70% **higher** than the overall GDP benefits. Exact GHG reductions for Africa, Indonesia and Other ASEAN not available to this study.
India		35% by 2035	+2.0%	
Indonesia		c.37% by 2035	+2.4%	
Other ASEAN		c.33% by 2035	+1.6%	
China		34% by 2035	+1.4%	
India	Enhanced MACC analysis	30% by c.2030	N/A	
China		30% by c.2030	N/A	

negative cost opportunities related to agriculture and forests, but found that very large emission reductions in these sectors (even vis-á-vis current emissions) were possible at a cost of <€20 per tonne (McKinsey & Co, 2009).[25]

Another set of studies, with a strong focus on assessing negative cost options has identified a larger set of opportunities. An assessment generated by the IEA (and built upon by the OECD) – the 'Efficient World Scenario' (EWS) – found even greater opportunity for negative cost emissions reductions, and a strongly positive impact on growth, although it does exclude emissions related to land use. The EWS looks at the impact of implementing only negative-cost, efficiency-enhancing mitigation actions. Across China, India, Africa and Southeast Asia, it shows that emissions vs. BAU can be reduced by about one third through such negative-cost, efficiency-enhancing mitigation actions. What's more, it shows strongly positive GDP impacts from these actions by 2035 (versus GDP under 'Current Policies'), estimated at 3.9% in India, 2.4% for Indonesia, >2% for least-developed African countries, >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.

Recently, even more comprehensive approaches have strengthened the argument that GHG mitigation can be good for economic growth in poorer countries, with a fuller treatment of major climate action co-benefits, including reduced air pollution, improved ecosystem services and reduced traffic-related costs. A recent World Bank study looked at existing opportunities in energy efficiency and clean transport identified through previous marginal abatement cost curve (MACC) work, but assessed the full economic impact taking into account various co-benefits. In India and China, its analysis implies that emissions could be reduced by roughly 30% (vs. BAU) at negative cost (Akbar et al., 2014). The study also showed that more than 60,000 lives could be saved in India, and almost 20,000 in China per year as a result of these actions.

24 Marginal Abatement Cost Curve

25 Note that with a fairly similar set of underlying assumptions based on proven, incremental changes, a macroeconomic study commissioned by India's Planning Commission (Expert Group on Low Carbon Strategies for Inclusive Growth) looked at the implications of reducing India's emissions by about 30% (vs. BAU), and found it had a negative overall impact on GDP in 2030 of -3.3% (Planning Commission, 2014).

The New Climate Economy Report also assesses the co-benefits of climate action more broadly, while considering a wider range of 'transformational' approaches. Its findings imply that the growth of global emissions to 2030 could be prevented in its entirety, and a significant reduction achieved, at no cost to economic growth. 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 that 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 imply that emissions reductions of up to 40% (vs. BAU) could be achieved through growth-enhancing mitigation opportunities in these countries (NCE, 2014).

Overall, recent and more robust studies suggest that those countries with large proportions of extremely poor people could reduce emissions against BAU by about one-third through growth-enhancing actions. It also appears that while clean energy and energy efficiency (industrial, agricultural, buildings and transport) are critical and popular opportunities, there are other growth-enhancing, albeit often more complex, opportunities related to low-carbon urban planning, transport, agriculture and forestry that are less explored.

b. Negative-cost opportunities can lead us toward zero net emissions

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 reductions 'required' by these countries is subject to considerable debate, often related to what a 'fair' division of responsibility would be between richer and poorer countries. Rather than enter into this debate, we look at the reductions assumed in the most common scenarios (IEA and IPCC). Such scenarios use different criteria to determine how much each country should reduce emissions, but they all call for relatively greater reductions in more developed countries, and seek to prioritise the lowest cost options.

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 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 are very varied. 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 see emissions increase by 15-25% against current levels, and fall by about 35-40% against BAU. Scenarios for Africa vary greatly,[26] but 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.[27] We also assume, conservatively, a slightly lower proportion of growth-enhancing actions in Africa, in line with the fact that this region appears to have a lower absolute amount of such opportunities in the IEA's EWS.

Table 5 (overleaf) compares the amount of available growth-enhancing mitigation actions to the amount of 'required' mitigation, with both presented as a percentage reduction against a BAU scenario. 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 for 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 choose the optimal pathway, and implement it efficiently).

It remains difficult to assess the overall impact of pursuing a zero net emissions pathway, even if many of the measures are growth enhancing and the remaining actions seem less likely to hamper growth than climate impacts under BAU. Although most of the transitions to zero net emissions by 2030 are achievable with growth-enhancing actions for regions with high levels of extreme poverty, a robust set of macroeconomic studies is not currently available (Stern, 2013; NCE, 2014). 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.

26 The IEA's 450 Scenario indicates relatively high reductions in emissions (37% against BAU), while it's recent 'Africa Century' scenario indicates continued increases in emissions through 2030 (7% growth vs. BAU). Given sub-Saharan Africa's very small contribution to emissions, global 450 ppm scenarios can include a fairly broad range for this region. We have chosen to be relatively conservative in assuming a scenario aligned with action across other LMICs, and one that is relatively close to IEA's most stringent 450 Scenario.

27 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), as well as the areas where it is most critical to avoid 'lock-in'.

Table 5. Proportion of mitigation actions necessary by 2030 for a zero net emissions pathway towards 450ppm in 2100 that are growth enhancing, for each country or region with extreme poverty (China, India, South East Asia and Africa)

	GHG reductions (vs. business as usual) possible through growth-enhancing actions	% reductions vs. business as usual in 2030 required for a 450 scenario	Proportion of zero-emissions actions that are growth-enhancing
China	-33%	-50%	c.66%
India	-33%	-40%	c.83%
South East Asia	-33%	-35%	c.95%
Africa	-25%	-25%	c.100%

Existing macroeconomic studies tend to estimate global impacts of +1% to -3% of GDP by 2050. Country-level macroeconomic assessments tend to fall into a similar range, with the higher cost estimates suggesting the loss of anywhere from 6 to 24 months of economic growth against BAU; although this does not take into account any costs of climate change in that period. In addition, macroeconomic modelling has also pointed to a potential 'stimulus' effect resulting from the increase in capital investment and the larger (on average) job creation from low-carbon rather than high-carbon investment (Oxford Economics, 2014, forthcoming; ILO, 2012). For developing countries driving to eradicate poverty by 2030, this means an additional boost to growth in the near term, with negative growth impacts (if they exist) being felt only much later (perhaps post-2030).

A large 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 that are 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 from these relative trade effects. There are likely to be both winners and losers, and the impacts for particular countries are worthy of further study.

Overall assessments suggest a positive net impact on economic growth in countries with many low-cost options, a slower reduction pathway (i.e. sub-Saharan Africa) and a small negative impact for countries with the biggest mitigation challenges (i.e. China). They also suggest a pattern of macroeconomic impact (low-cost measures and stimulus in near term, with cost impacts in medium term) that would, on average, be more conducive to the eradication of poverty by 2030.

Nevertheless, given that all regions will require some actions that may incur costs, and that such actions could increase beyond 2030, it is important to look more closely at their nature and potential impacts. The successful achievement of a zero-zero pathway will require the careful management of these positive-cost actions to ensure continued moderate, sustained growth in countries with significant levels of extreme poverty.

c. Identifying the opportunities for negative and low-cost mitigation

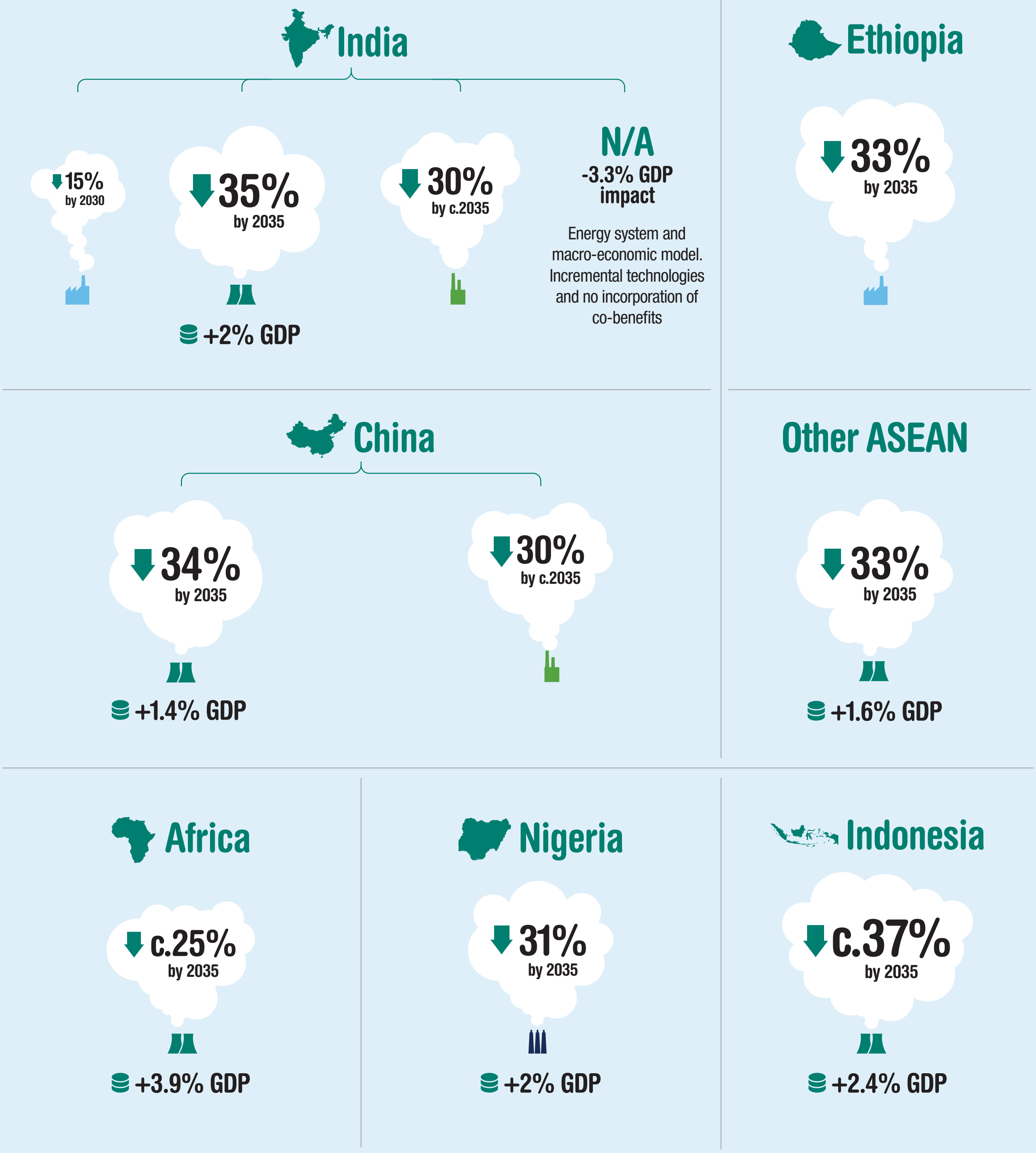
For most countries with large numbers of people living in extreme poverty, mitigation action in buildings, industry, waste and transport sectors will have broad, and often quite strong growth-enhancing impacts.[28] This is an important insight, and stems from the fact that these sectors have large efficiency improvement opportunities and/or large co-benefits from mitigation (for example, reduced air pollution, reduced congestion, improved sanitation, etc.). Achieving emissions reductions may still be challenging, however, particularly where significant structural shifts are required. Urban development may be the most extreme example of a large inherent opportunity that faces a large implementation challenge. While there is significant evidence of the benefits of a compact and connected urban form, the sophisticated and long-term planning required to create such a form, combined with the enormous investment commitments, the inertia of incumbent political interests, and the rapidly changing situation on the ground leaves many cities either paralysed or perennially behind the curve. Nevertheless, there is no fundamental trade-off between growth and emissions reductions in these sectors, provided the institutional capacity and necessary financing are available.

28 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.

Estimates of cost-saving opportunities for GHG emission reduction in developing countries

This infographic illustrates the negative cost (i.e. cost-saving) opportunities for GHG emissions reductions, measured as a percentage of emissions reduction against a business as usual emissions scenario. The impacts of these opportunities on GDP are provided where available.

MACC - incremental improvements to BAU
IEA Efficient World Scenario
Variety of sector models
Enhanced MACC analysis



In contrast, most of the potentially positive-cost actions required for a zero net emissions, 450 ppm scenario are either in land-use[29] or energy-supply systems. To understand the potential extent and distribution of these additional costs and trade-offs, it is worth looking at these sectors in more detail.

Land-use sectors remain subject to a good deal of uncertainty in terms of the potential costs and benefits of mitigation action. On the one hand, many land-use measures appear to be relatively affordable. 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 & Co, 2009; Cervigni et al., 2013). In the forest sector, negative emissions 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.[30] Encouragingly, these studies also suggest that the required increases in food production are possible even 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 resilience.

Other studies show a relatively greater proportion of land-use mitigation action as positive cost. Fundamentally, this appears to be the result of the greater technical challenge involved in achieving efficiency improvements and the assumed ability to continue depleting natural resource with limited near-term impacts. The diversity of measures required across different geographies and sub-sectors and the challenging implementation environment, often involving a large number of small actors, increases the uncertainty around the macroeconomic impact of climate action in these sectors.

Achieving both growth and emissions reductions in the land-use sector appears possible, but it will require a structural shifts in existing growth patterns. Low-carbon (or 'climate smart') agriculture requires a significant change in the techniques and patterns of productivity growth that have driven gains during the 'green revolution' of the past decades. Put simply, it requires a move from increasing inputs like fertilizers and pesticides, to increasing technical inputs that improve the efficiency of water and fertilizer 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. This requires a broad increase in both the physical and human-capital investments made in land-use sectors in poor countries that are limited at present. For some actions, it is also likely to require increased public spending and significant international support.

Reducing emissions from energy continues to represent the biggest challenge in terms of the relatively high underlying cost of emissions reductions, and the large physical capital investment required. It drives the negative GDP impacts found in most studies, and for some countries (especially MICs) it is conceivable that these costs could add up to a few percentage points of GDP by 2030, and potentially outweigh the benefits of growth-enhancing actions. 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, the additional costs associated with sovereign risk and currency fluctuations can increase the cost of renewables by c.25% (NCE, 2014). From the perspective of achieving global zero net emissions, 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. The actions of these two countries matter deeply – even more than the actions of sub-Saharan Africa or the rest of Asia. In the case of India, there also remains the dual challenge of providing direct energy access to around 400 million people who currently lack it, while simultaneously moving the country's energy supply, for both direct access and industrial purposes, to a low-carbon trajectory.

Nevertheless, the energy-supply sector has shown a steady improvement in recent years in the cost of low-carbon technologies, and in the cost of financing. Compared to even just five years ago, the cost of renewable energy has fallen considerably, as the gap between renewables and high-carbon alternatives has narrowed significantly. Improvements in the capacity to procure and integrate utility-scale renewables, and to overcome the technical and financing challenges to off-grid renewables has led to an increasing number of negative-cost opportunities in some countries. 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 (e.g. well over 50% in Nigeria) (Cervigni et al., 2013). In addition, more suitable financing instruments for renewable projects are being introduced, and have the potential to be scaled

29 Technically referred to as the Agriculture, Forestry, and Other Land Uses (or AFOLU), we simply refer to 'land use' to describe this sector.

30 These represent very rough estimates, as the BAU assumptions varied greatly across studies. With regards to negative emissions in the forest sector, it is worth noting the significant variation between countries like Ethiopia where 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%).

up rapidly over the next few years toy reduce a large portion of the additional financing burden.

Similarly, the full cost of high-carbon energy supply, especially coal, is much better understood. These include the externality costs of coal (e.g. air pollution and water use), the costs of energy insecurity and the risks of stranded assets. India and China in particular face mounting costs and risks as their air pollution levels remain many times higher than WHO recommendations, and their 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). While such roll-back costs would not create poverty directly, the value of such stranded assets is large when compared to the costs of measures to eradicate poverty.

Overall, while the energy-supply sector has the potential to harm growth, 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. This is crucial, because the poverty eradication challenge will be largest in these countries. 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.

2. A zero net emissions pathway means positive distributional impacts, if well integrated into zero-poverty measures

a. The potential for Zero Zero co-benefits

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 the countries that need it most. Nevertheless, as we saw in Section III, 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 emissions pathway might affect this distribution.

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, and reduce the costs of public services to poor people
- 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, and none that 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 upon which poor people depend disproportionately for their livelihood and well-being. Improvements to crop rotations, minimum tillage, more precise use of fertilizers and agrochemicals, micro-irrigation, etc. 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, 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, and might improve educational attainment and longer term productivity (Wheeler et al., 2010).

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). Again, as we saw in Section III, the development of infrastructure and public services (such as energy services) and employment opportunities that are more directed at poor people will be necessary to reach the goal of zero extreme poverty. Finally, the world's current high-carbon (e.g. fossil-fuel and fertilizer) subsidies benefit the rich disproportionately. By removing such subsidies and using the revenues gained to provide better targeted technical support or direct transfers to the poor would both reduce emissions and bring large poverty alleviation benefits at no net cost (World Bank, 2013a; Clements et al., 2013; Independent Evaluation Group, 2008).

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, they are more likely to serve the better off than poor people. Third, a number of actions could increase the prices of goods and services including food and energy, upon which poor people spend a large portion of their income. Finally, measures to remove subsidies on goods that poor people consume, such as fossil fuels and fertilizer, can harm poor people if there is no compensation for subsidy removal through other transfer methods.

b. The most 'regressive' mitigation options could be structured to benefit poor people

It is striking that most mitigation actions that could favour the better off could 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. But this means that project choice, design and implementation must try to optimise these benefits by ensuring that services reach poorer and often informal settlements, and that pricing schemes ensure affordability for 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 from which many of the extreme poor could benefit (Meinzen-Dick, 2009; Galiania and Schargrodskyb, 2010). This is crucial, as we have seen the importance of accumulating capital assets to sustained poverty eradication.

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 that zero-emissions actions are pro-poor are exactly the same as actions that should be targeted by poverty-alleviation policies in any case: 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 6 sets out some key mitigations actions, their distributional impact on the extreme poor, and additional policy considerations to ensure that they are pro-poor.

Table 6. Direct impact of key mitigation actions on those living in extreme poverty

Mitigation action	Direct (distribution related) impact on 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.
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 needs to be 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.
Reduced subsidies for fossil fuels and fertilizer	– Better-targeted technical and cash transfers increase the income of those in extreme poverty.	– Depends on replacing regressive subsidies with better-targeted assistance.
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. – 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.

VI. The unavoidable transitions

If we achieve zero net emissions by 2100, the ways in which energy, food and human habitat are planned, produced, and consumed will look radically different. While the broad compatibility of the goals zero extreme poverty and zero net emissions has been presented, the treatment of the pathways to these goals do not sufficiently address the social and economic systems that will need to change under any zero net emissions scenario. These three transitions are presented in this section to demonstrate that existing answers are not enough to turn theory into reality. They parallel the transitions that will be needed in energy, land use and cities highlighted in the New Climate Economy Report (NCE, 2014). However, this paper focuses on the added ambition that is needed to make these transitions serve the poor. In so doing, it focuses on the human needs within these systems: all people need energy, food and habitat for their basic welfare.

The transitions required in energy, agriculture and habitats could occur in any number of different ways. They are also likely to be context specific. It is fair to say, however, that the details have not yet been worked out no matter which context is considered. This section outlines these transitions and their contributions to economic growth and the assumptions that will either lead to – or away from – the objective of Zero Zero.

1. The energy transition

a. Energy, poverty, and climate change

Energy for electricity, to drive machinery and to generate heat are critical enablers of economic growth, and rising energy-use per capita always accompanies rising income per capita in the early stages of development. Historically, rising energy use has been coupled with GHG emissions, and it now accounts for about 40% of global emissions (Foster and Bedrosyen, 2014). Although emissions from OECD countries are projected to decrease slightly by 2035, non-OECD energy demand and GHG emissions are projected to increase by around 66% in the same period under a BAU scenario (IMF, 2014).[31] All scenarios for zero net emissions require decarbonisation of the energy system that would involve a major transition away from coal and other non-renewable energy sources and towards renewable energy sources (IPCC, 2014b). Although the poorest countries, especially in South Asia and Africa, still have a window of perhaps 15 years in which to continue increasing their emissions, ensuring rapid decarbonisation post-2030 will require immediate and tough choices about energy policy and infrastructure priorities. Middle-income countries with large numbers of extremely poor people (such as China, India, and some parts of Southeast Asia) need to begin this transition at scale right now.

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[32] contributes to both income and multi-dimensional poverty. Providing poor households with access to secure and reliable energy can improve their economic productivity, access to information, education and health (Lockwood and Pueyo, 2013). Increasing more general energy access also represents a critical enabler of broader economic development, prosperity and progress towards a number of Millennium Development Goals (UNDESA, 2013). In the words of the UN, 'energy is the golden thread that connects economic growth, increased social equity, and an environment that allows the world to thrive. Development is not possible without energy, and sustainable development is not possible without sustainable energy.' (UN, 2012).

b. The promise of sustainable energy access

'Sustainable energy access' is widely regarded as an important policy solution for the achievement of the Zero Zero goals. Ban Ki Moon's 2011 UN Sustainable Energy For All Initiative Vision Statement introduced the solution formally, with the intention of spurring 'concrete international action to address the initiative's three objectives – energy access, energy efficiency, and renewable energy – in an integrated way' as a way to 'defeat poverty and save the planet' (UN, 2012; Moon, 2011). In 'The Future We Want', the Rio+20 outcome document, world leaders also affirmed the 'critical role that energy plays in the development process, as access to sustainable modern energy services contributes to poverty eradication, saves lives, improves health and helps provide for basic human needs.' 'The Future We Want' also emphasised the challenge of access to energy services, in particular for poor people, who are unable to afford these services even when they are available (UN Rio+20, 2012).

31 Changes are against 2011 levels.

32 '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 (via products from manufacturing, jobs, etc.)

Table 7. Trade-offs between energy poverty pathways

Mechanism / type of energy generation	Use	General improvement	How does it alleviate poverty?	But consider these assumptions:
On-grid electricity	Industrial uses	Increased production and productivity	Growth of the broader economy, job creation and improved public services.	Assumes policies that redistribute benefits to poor through public services, and/or open economic opportunities to poor people.
Large-scale thermal energy	Industrial uses	Increased production and productivity	Growth of the broader economy, job creation and improved public services.	Assumes policies that redistribute benefits to poor through public services, and/or open economic opportunities to poor people.
On-grid electricity	Household uses	Increased productive or consumptive purposes	Improved health, education, access to information to improve social development. Improved productivity to raise income.	Assumes transmission, electrification, and affordable connection; many purported benefits assume fuel switching for cooking and heating to electricity.
Off-grid electricity (mini- and meso-grid)	Industrial or small-scale productive uses	Increased productivity	Improved productivity to raise income.	Assumes sufficient wattage for all productive purposes.
Small scale off-grid electricity (micro-grid and household) technologies)	Household uses	Ability to consume electricity	Improved health, education, access to information to improve social development	Assumes sufficient wattage for required consumption. Assumes costs are affordable and that level of consumption will rise over time.
Household thermal energy (cooking and heating)	Household uses	Increased productive or consumptive purposes. Improved thermal efficiency, pollution reduction.	Improved health and social well-being	Assumes community uptake of new modes of cooking.

Yet, the term 'sustainable energy access' fails to distinguish major policy choices and technology options, each of which has distinct pathways to poverty reduction. 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. There are trade-offs between different energy policies, (see Table 7), and it is important to understand these trade-offs and their resulting pathways to the achievement of the Zero Zero goals.

c. The opportunity: prioritising direct access

'Energy access' to reduce poverty is often discussed as household access to modern energy services, sometimes referred to as direct energy access. More than 2.7 billion people – the vast majority of them poor – lack any access to clean cooking facilities and 1.3 billion lack access to electricity at a household level (IEA, 2013).

In terms of the potential challenges and trade-offs, it is important to understand that ensuring direct energy access for all households would create relatively few emissions. The IEA Energy For All Case suggests that the completion of the electricity-access portion of this goal (100% household electricity access by 2030) would increase emissions to only 0.7% above the New Policies Scenario levels.[33] This minimal increase is a result of the low level of energy used per capita by the poor, the lower emissions intensity of distributed electricity solutions (i.e. micro- and off-grid), and the high adoption rates of renewables in those circumstances (IEA, 2011a). Yet it is important to note that this says nothing about the significant pro-poor,

33 The New Policies Scenario shows emissions reductions by 2030 that are 11% greater than the Current Policies Scenario we use as our business as usual scenario in this paper. The 0.7% increase against a New Policies Scenario would correspond to about a 0.6% increase against a Current Policies Scenario, and a 1% increase against a 450 ppm ('zero-emissions') scenario.

and climate-compatible energy access gains to be made by focusing on household thermal-energy needs (largely composed of efficiency changes) that are unlikely to be met by electricity except over the very long term.

The IEA estimates that around 60% of direct electricity access needs would be best served by distributed solutions (IEA, 2011b). This is because many of the extreme poor live in remote areas that are completely unconnected to the grid, and that distributed renewables are often cheaper than other distributed solutions (e.g. diesel generators) and can provide access to energy far more quickly than grid expansion (IEA, 2011b; REN21, 2014; Vagliasindi, 2012; Cust et al., 2007).

The IEA estimates that around 40% of households that do not have electricity at present would be best served by the extension of the traditional grid, which would require some expansion of generation capacity (and emissions), but the level of supply required to meet household demands is relatively low. Much of the challenge will be the corollary distribution infrastructure and the policies needed to reach the extreme poor. Generation will require distribution and electrification. Even electrification does not mean much if the resulting service is poor and intermittent or if tariffs and grid connection fees are exorbitant, as this could have a dramatic impact on the productive use of electricity and the ability of poor people to consume energy (Nussbaumer et al., 2012).

Studies in several countries have shown that very high numbers of households remain unconnected even after several decades of village electrification: in India, 90% of villages have electricity, but only 40% of rural households have access (World Bank, 2008a). Policies that subsidise connection tend to reach poorer households, but will slow the rate of connection (using resources that could be used for grid expansion). Even once connections are established, 32% of developing countries have reported at least 20 hours of outage a month, with a potential impact on productivity (Economic Consulting Associates, 2014).

Some commentators argue that delivering low wattage distributed energy solutions 'does nothing more than shine a light on poverty' (Yumkella, 2009 in Bazilian and Pielke Jr., 2013). The low capacity of many distributed electricity technologies is said to limit options for real transformational change by limiting economically productive transformations (Bazilian and Pielke Jr., 2013). Evidence does suggest that consumers will use their access to electricity differently: poor households often only use electricity for final consumption-related purposes, such as lighting, mobile-phone charging and TV. Wealthier households are more likely to use electricity for intermediate productive purposes such as agricultural processing or irrigation, because they can afford the required technology (World Bank, 2013c).

Nevertheless, the value of energy access for basic services, such as lighting, should not be understated as a first step away from abject poverty. Poor households that use electricity for final consumption-purposes often do so precisely because of the immediate welfare benefits that they entail, and such consumption often facilitates productivity gains in other aspects of the household economy. Such systems are proving to be cost-effective, and emissions-reducing ways to achieve these initial benefits. Finally, the deployment of low wattage distributed energy can also be a first step towards the more robust development of energy systems in rural areas. Moving from lower to higher wattage units to micro-grids, and then to interconnected micro-grids can be a natural progression in line with the optimal development of a low-carbon electricity system. Table 8 summarises the most common uses of electricity as users move up through five tiers of demand.

Authors such as Bazilian and Pielke, Jr. (2013) are right to stress the distinction between investments in these micro-changes and the macro-level policies that underpin industrialisation, but wrong to underestimate the significance of the former for human welfare through both consumptive and productive uses, especially in rural areas.

Improved direct energy access also requires the prioritisation of access to modern, and more efficient, forms of household thermal energy[34], given that electricity has a limited impact on thermal fuel choices. The statistics on the scope of energy poverty alone speak to the limited impact electricity has on cleaner cooking: the number of people who lack access to clean cooking facilities is twice as high as the number of people who do not have electricity. Indeed, the penetration rate of electricity for cooking in households in developing countries is quite low – often less than 1% (World Bank, 2013b).

Newly electrified households are often unable (the low wattage systems used in rural areas cannot support the substantial energy requirements of cooking with electricity) or unwilling (users cite the high cost of on-grid electricity compared to biomass and some simply prefer traditional cooking methods) to switch away from biomass (World Bank, 2013b). Much of the literature references an energy 'ladder' with three 'rungs' that poor people can climb to meet clean cooking/heating needs: 1) biomass, 2) kerosene or charcoal, and 3) liquefied petroleum gas, electricity or solar. The exact 'tipping points' at which a household steps up to the next rung are debated, with the initial step from rung one to two catalysed by reaching a per capita income of around $200. The step from the second to the third rung

34 This is often referred to in terms of 'cleaner cooking services' or even 'clean cook stoves', but this paper focuses on the form of energy rather than the purpose (cooking) or technology (cook stoves) to encompass the general needs for thermal energy at the household level. This is not to be confused with thermal-based utility-scale power generation.

Table 8. Common uses of electricity as users move through tiers of electricity service demand

Tier 0	Tier 1	Tier 2	Tier 3	Tier 4	Tier 5
None	Lighting for specific tasks AND phone charging (or radio).	General lighting AND television AND fan (if needed).	Uses in Tier 2 AND any low-power appliances.	Uses in Tier 3 AND any medium-power appliances.	Uses in Tier 4 AND any high-power appliances.

Source: World Bank, 2013b

is much higher, with the tipping point occurring closer to $5,000 per capita (Gangadharan and Valenzuela, as cited in Oparinde, 2010).

More research is needed on what drives the shift from biomass to electricity for cooking, and therefore, on the impact of electrification on thermal energy poverty. In the meantime, provision of low-cost, cleaner cooking stoves and sustainable charcoal technologies, for example, are critical to create an alternative 'middle rung' that enables an energy transition that improves the lives of poor people, and that reduces the emissions of a more traditional shift to kerosene or charcoal.

In sum, direct energy access plays a critical role in reducing extreme poverty in the short term that is also highly compatible with a trajectory towards zero net emissions. This is particularly true for low-wattage distributed renewables, and with clean cook stoves or fuel switching to denser and more efficient fuels. These interventions provide an incremental shift that can improve the productivity and welfare of poor households dramatically, and that shift can be crucial to their greater participation in the macroeconomy. They represent an important win-win opportunity, and a first step toward a broader transition.

d. The challenge: low-carbon energy for industrialisation and sustained economic growth

Direct energy access alone is unlikely to provide the conditions of sustained, moderate growth that are necessary to maintain poverty reductions over time. What's more, it is not where the most serious trade-offs with a zero net emissions pathway are to be found. In a broader sense, energy access is an issue related to macro-level electricity generation gaps or the unreliability of the system, leading to lower consumption of electricity as an input to economic activity, and, in turn, to reduced productivity. Generation gaps will affect developing countries in particular, and the promotion of 'energy access' is often conflated with improving 'indirect' energy access.

Empirical evidence suggests a strong correlation between GDP growth and energy consumption, although the causal arrow of this relationship is less well established: it is unclear whether energy generation makes economies grow, whether growing economies consume more energy, or whether the two factors are mutually reinforcing (Economic Consulting Associates, 2014; UN, 2012). Nevertheless, increased energy availability is an essential corollary to industrial production.

The prevailing development assumption is that poor economies will need to achieve the power generation capacities of more industrialised economies to create the conditions of productivity and employment that can sustain consumption well above the poverty line. This will, it is argued, lead to the growth of the broader economy, job creation and public revenue for improved public services. It could also impact households by increasing employment in industrial activities and the services that support those activities, thereby increasing incomes and expanding economic opportunities to reduce poverty (Economic Consulting Associates, 2014). Finally, as we noted above, the 'macro' access story plays an important role in the 'micro' (i.e. direct) access story for the 40% of those households that do not have direct electricity access and that might rely on grid expansion.

If macro access is to support poverty eradication it must be accompanied by the right enabling environment, which in turn relies on sufficient government capacity. Public policy choices are necessary to enable: 1) a policy and legal framework and provision of technical expertise for the expansion of generation, transmission and distribution capacity to enable industrial growth; 2) capacity building and industrial policy tools to ensure that industrial growth creates employment benefits among poor people; 3) capacity to mobilise revenue from the private sector (e.g. taxes) to support public services aimed at poor people, and 4) proper policy, management and provision of those public services to ensure that poor people have access to public goods and services (UN, 2012).

There are many challenges to poverty reduction through 'indirect energy access'. First, it is difficult for a state to create and support the necessary enabling mechanisms described above in order to attract investment in electricity generation. The time horizon for the creation of such a supportive environment is very long, as it does not stop at the creation of new policies, institutional frameworks and governance mechanisms, but also includes effective implementation. Second, even if electricity generation is increased and spurs industrial growth, the benefits may not reach poor people proportionally. In the medium term, filling generation gaps and improving the reliability of the grid can drive sustained aggregate growth, but policies focused on poor people are required to overcome the challenges specific to this group, including the equitable distribution of economic opportunities, such as labour, and the affordability of access to grid-connected electricity. Empirical evidence suggests that without the institutional capacity and political mandate for redistributed policy interventions, a 'trickle down' approach to access may lead to more unequal growth (Yumkella, 2011; Modi et al., 2006), bringing us back to the challenges highlighted in Section III of this paper.

Alongside these challenges to ensuring macro energy access results in broad-based poverty reduction, there remains the challenge of ensuring that the expansion of macro access is low carbon. High-carbon sources currently provide 82% of global primary-energy consumption, and demand for them is set to increase by 40% over 2011 levels by 2035 under current policies. Approximately 90% of the growth in demand for energy over the period from 2011 to 2035 is projected to be from non-OECD (emerging) markets (IEA, 2013). All scenarios for zero net emissions require a major shift away from non-renewable energy sources by 2050.

A few synergies may exist between the goals of zero extreme poverty and zero net emissions in relation to macro access. First, replacing very dirty (usually coal-based) plants with low-carbon alternatives can both decrease emissions and improve air quality, with large benefits for the health of poor people. Second, some have argued that low-carbon systems create more employment opportunities than high-carbon systems, although the full macroeconomic impacts, and the specific impacts on the employment of poor people have not been explored sufficiently. At the same time, the most significant additional cost related to a low-carbon transition is associated with the deployment of large-scale renewables, rather than the challenge of ensuring that macro energy access benefits poor people. Finally, countries that do not begin a low-carbon transition quickly enough could face the risk of locking-in assets that will become stranded before the end of their useful life. Whether the financial burden of this falls on the countries themselves, or on the international community, the cost to countries by the 2030s could be significant, and must be weighed against the short-term cost benefits of choosing high-carbon options.

There are few robust assessments of the distribution impacts of the deployment of higher-cost renewables or options to alleviate these impacts. Our assessment of the macroeconomic impacts of a low-carbon pathway for poorer countries suggests that the impact of energy-system decarbonisation on poverty alleviation would be small. One assessment conducted in India of the impacts of renewable energy policies on poverty confirms this initial conclusion (Parikh et al., 2013). It is particularly instructive because, as noted in Section V, India has relatively fewer negative cost options. Although the study found that renewables policies would reduce macroeconomic growth by almost 2% by 2030,[35] it also found that the impacts on poor people would be extremely small. Of particular interest is the study's comparison of the impacts of a generic redistribution policy on poverty reduction vs. the impact of renewable-energy policy. It found (in line with our conclusions) that modest transfers could reduce poverty much faster than economic growth alone – achieving the eradication of poverty about five years sooner (by about 2025 instead of 2030). In contrast, the introduction of renewables had a barely noticeable impact on poverty eradication, setting back its achievement by a few months, at most.[36]

Nevertheless, both poverty eradication and emissions reduction put additional resource demands on the same energy system, and without care to ensure that neither goal is compromised, it is possible that one might 'crowd out' the other. While the rapid alleviation of extreme poverty and climate goals can be quite compatible, via the expansion of direct sustainable access, achieving the expansion of macro-level energy access to enable broader growth while achieving a pathway of zero net emissions will require the comprehensive and far-sighted planning of energy systems, and a careful management of trade-offs. Many LDCs have a longer transition window when it comes to reaching a zero net emissions pathway, but it is critical that they make good use of this window to prepare effectively for this transformational shift.

e. Conclusion

The interface between energy access, overall development, poverty eradication and emissions reductions is one of the most complex and challenging. On the one hand, there is some evidence that the impact of renewable energy on a large portion of the extreme poor is either net-positive, or only slightly negative, largely because of the importance of distributed energy access for the eradication of extreme

35 The model used for this study was similar to the one used for the Low-Carbon Expert Group study cited above, and it shows relatively large growth impacts when compared to the other studies discussed.

36 The level of renewables examined in this study was only about one-third to one-half of what would be required by India in a zero-emissions pathway. The study found that such renewables deployment would set back poverty eradication efforts by about one month [our calculations]. We have extrapolated this to a 'few months' for a scenario in which the even greater deployment of renewables would take place.

poverty and the competiveness of low-carbon technologies. On the other hand, a sustainable energy transition that targets direct access and industrialisation simultaneously will need to focus both at the micro and the macro levels, with distinct challenges at both levels. In addition, although there are inherent synergies, particularly for direct energy access, there are greater inherent trade-offs for indirect energy access than there are in the urban or agricultural systems. In many respects, multiple goals have to be achieved at the same time, and each requires a significant amount of additional resources.

While the degree to which increasing access to distributed energy can reduce poverty is still disputed, there are strong reasons to pursue this as an immediate priority (Craine et al., 2014). Distributed household energy access – thermal and electric – can move the poor up the energy "ladder", 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 – even in a high-carbon system – are relatively small compared to the poverty-reduction benefits. 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.

Macro energy access, industrialisation and consequent growth are crucial public-policy priorities that can also have significant impacts on poverty reduction, but it has clear limits in terms of addressing the energy access issues of the poor, particularly the rural poor. With a 15-year time horizon and an ethical imperative to shift the poorest people out of abject poverty, specific policy priorities are needed to improve their consumption and well-being at speed. A specific focus on the expansion of direct access, through a combination of distributed energy and expanded distribution networks, is a clearer priority for poverty alleviation than trying to 'convert' industrial growth from high levels of generation expansion into the reduction of extreme poverty. Nevertheless, industrial generation is still crucial for the longer-term scenario of sustained growth and poverty reduction, provides unquestionably important benefits for other segments of the populations, and is unlikely to be compromised by policy makers. To address both energy policy goals, financing and aid mechanisms are needed that eliminate the potential trade-off between them, particularly for the poorest countries. Given the evidence from Section V, the investment in ensuring poorer countries achieve this Zero Zero pathway are likely to be relatively modest through 2030, but they require the significant development of institutional and technical capacities.

2. The agricultural transition

a. Agriculture, poverty and climate

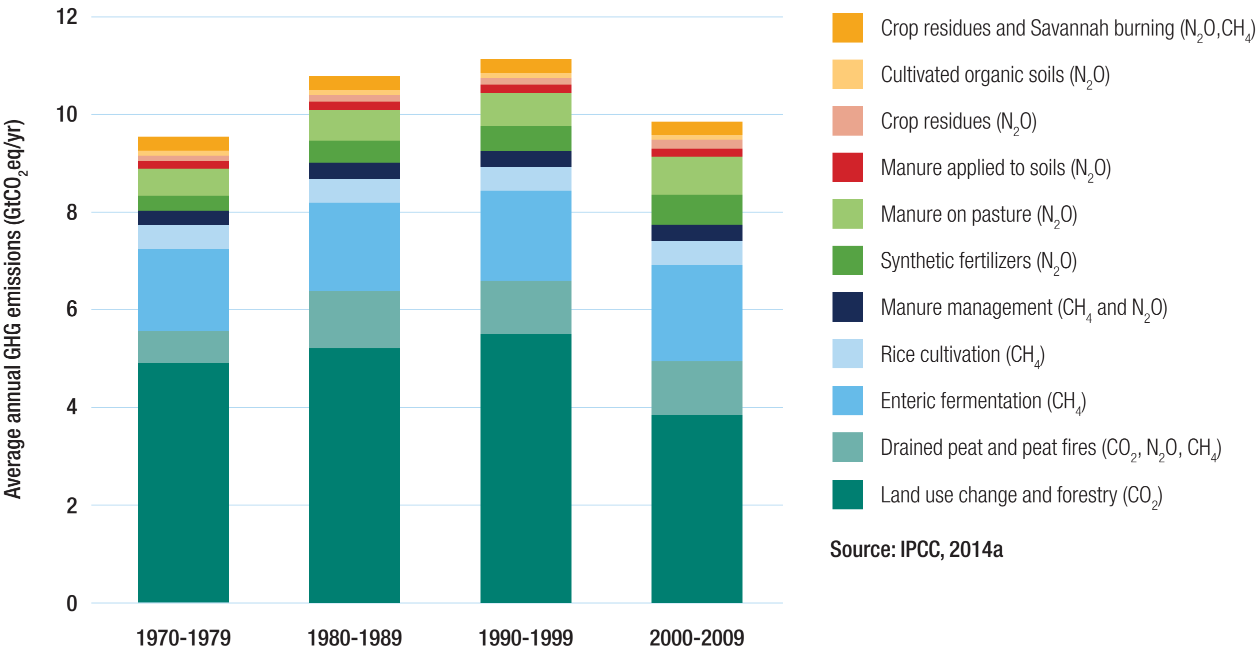
Agriculture is an essential component in any discussion about global poverty reduction. Farming is the mainstay of many of the poorest people in the world, most of whom are rural-based farmers and rural areas account for 75% of people living on less than $1 per day (UNDP 2007). Recent declines in the poverty rate have been the result, primarily, of falling rural poverty, rather than falls in urban poverty, and much of this decline relates to better conditions in rural areas rather than migration to cities (World Bank, 2008b). Farming also has 'special powers' in reducing poverty: GDP growth from agriculture has been shown to be at least twice as effective in reducing poverty as growth originating outside agriculture and up to 3.5 times more in China (World Bank, 2008b; Godfray et al., 2009).

At the same time, food security faces an uphill battle. Although fewer people are hungry – hunger has fallen by 17% since 1990 – one in every eight people, some 842 million in total, still don't get enough food (FAO, IFAD and WFP, 2013). Enough food is being produced to feed the global population, raising the question of the role of income poverty in malnutrition and the importance of food equity and food rights, but a challenge remains for sufficient food production 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, given that the global population will grow by a further third by 2050. Feeding 9.1 billion people will require a 70% increase in global food production on 1990 levels; and doubling of food production for developing countries (Godfray et al., 2009). The global population may grow beyond this (Gerland et al., 2014), providing further challenges for food security.

Agriculture is already responsible for a significant amount of GHG emissions. Increasing crop production globally means that the agriculture sector (including livestock and forestry/land-use change) is now responsible for around 25% of total GHG emissions – a sizeable chunk as a result of significant dependence on fossil fuels for mechanised and chemical inputs and some relatively high emission sub-sectors/practices (IPCC, 2014a). Activities that emit GHGs within the sector include: land-use activities in crops, forests, grasslands and wetlands; conversion of forest lands to crop/pasture; livestock gut processes (especially cattle); rice cultivation; and manure storage and biomass burning (see Figure 7, overleaf).

However, the agriculture and land use sector is one of few that can also contribute significantly to carbon emissions reduction globally through natural carbon sinks (IPCC, 2014a).

Figure 7. Greenhouse-gas emissions from the agriculture, forestry and land-use change sectors



Source: IPCC, 2014a

b. The need for greater productivity

Given the expected increase in demand for food, the agriculture sector is under pressure to produce more, and fast. Increasing agricultural productivity is an obvious choice, and an essential factor in meeting these growing needs (HLPE, 2013). It has been done before, and successfully. Agriculture has changed significantly in the past 50 years in many parts of the world through intensification and production has increased by 162% (Burney et al., 2009). This has been driven by the adoption of higher-yielding varieties, the increased use of pesticides and fertilisers and improved access to irrigation and mechanisation – part of the 'Green Revolution'. In agriculture-based countries, where most poor people live in rural areas and where agriculture accounts for about one-third of GDP, agriculture is, therefore, the lead sector with the greatest potential for overall economic growth and for poverty reduction.

Intensification is also promoted as one way to reduce GHG emissions from agriculture. Burney et al. (2009) have shown that, in the aggregate, intensification practices in agriculture since the 1960s have avoided additional emissions that would otherwise have come from the increased conversion of land to extensive agriculture in order to feed the current population. But ramping up productivity may also increase GHG emissions. If achieved through increasing high-productivity agriculture, further profit-seeking land conversion might result, increasing emissions. In this scenario, the recently-promoted approach of 'sustainable intensification' ('producing more food from the same area of land while reducing environmental impacts') will not be enough to reduce emissions from the sector as a whole (Godfray et al., 2010; The Montpellier Panel 2013; Purdue University, 2014).

A changing climate could also have serious impacts for this highly climate-sensitive sector, and particularly for rain-fed agriculture. Widespread impacts on yields and ultimately on GDP are expected: disaster-risk reduction and adaptation rank highly in current agricultural concerns. Increasing agricultural productivity, food security, reducing poverty and increasing economic growth in agriculture may appear, at first sight, to be overlapping policy initiatives for the sector. But there are significant differences in policy focus and practice that would result from these alternative, but overlapping, approaches.

c. The opportunity: climate-smart agricultural intensification within boundaries

Between 70% and 80% of food is produced by about 500 million smallholder family farmers worldwide (FAO, 2014). With 1.3 billion smallholders and landless workers worldwide, a focus on smallholder production is considered the most robust way to stimulate poverty reduction through increased productivity and economic growth: '[I]mproving the productivity, profitability and sustainability of smallholder farming is the main pathway out of poverty in using agriculture for development' (World Bank, 2008b, p. 10). Productivity gains for agricultural smallholders also provide a foundation for the more equitable distribution of economic growth. In countries across the world, the family farm model endures. Owner-operators know their farms, soils and climates, can adjust their labour supply according to demand and have greater investment in the outputs and profitability than wage workers on commercial farms (Deininger and Byerlee 2011). Smallholder intensification in Asia during the Green Revolution drove agricultural growth, and, although evidence remains preliminary, small-scale farming is found to be no obstacle to growth in Africa (Wiggins, 2009).

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. Agricultural practices that improve productivity at the farm level can help to reduce emissions or even sequester carbon, using more efficient agricultural practices and improved conservation of natural resources. Approaches based on low emissions and productivity enhancement in the sector include better nutrient management (changes in fertiliser application), the use of more nitrogen-efficient plants, changes to livestock management and selection, and manure management.

Such sustainable agriculture, 'conservation' agriculture, climate-smart agriculture[37], agroforestry systems and improved feed-management systems for livestock are already being practiced across the world, particularly where they have been shown to produce increased yields. Conservation agriculture has not been applied at scale, but it has not yet been backed by significant policies and institutional support through governments in a sustained fashion. Nevertheless, the current area under conservation agriculture amounts to about 7% (or 106 million hectares) of the total land under production (Kassam et al., 2009). Some 60% of cropland area in southern Latin America is now 'no-till' (retaining crop residues on the surface of the soil and controlling weeds with chemicals, mulch or cover crops) (Kassam et al., 2009), and farmer-led innovations in Burkina Faso and Niger have led the 're-greening of the Sahel' (Reij et al., 2009). In many countries conservation practices are still at the pilot level and are led by relatively small but vibrant NGOs and funded services such as the Conservation Farming Unit originating in Zambia (CFU, 2014). Well documented evidence for improvements in yields and profitability in Zambia and Malawi exist, but conservation agriculture can show weaker benefits than, say, agroforestry, and therefore it can be constrained in its uptake (Kaczan et al., 2013).

Some of the 'lowest hanging fruit' in agriculture, from an emissions-reduction perspective, will have very little impact on the extreme poor. The livestock sector, for example, is responsible for 14.5% of human induced GHG emissions (Gerber et al., 2014). Beef and dairy cattle production, in particular, creates disproportionately larger emissions per unit of yield than any other protein/livestock source and is responsible for nearly two thirds of the sector's total emissions (National Geographic, 2014). Most of this is because of feed production and processing, and stomach (enteric) fermentation processes. Fossil-fuel use along the sector supply chain is also responsible for about 20% of emissions across all categories. A recent report by the Food and Agriculture Organization of the UN (FAO) on livestock emissions showed that a 30% GHG emission reduction would be possible from existing livestock emissions if the best technologies and practice were adopted by the 10% 'worst' emitters in a given system, region and climate (Gerber et al., 2014). Recent evidence from Brazil showed that 90% of Nationally Appropriate Mitigation Activities (NAMA) targets could result from the sustainable intensification of cattle ranching, equating to a reduction in emissions of around 900MtC02 by 2020 (Cohn et al., 2014). While there may be trade-offs between intensification of the livestock subsector and emissions, the vast majority of consumption for beef and dairy is not for the extreme poor, but rather for the growing middle classes (Hertwich et al, 2010).

Some of the strongest synergies between agricultural system productivity and a low-carbon pathway are beyond the farm level. A number of wider issues are important here, such as post-harvest waste, which averages 30% of production. In Ethiopia, a country with significant food insecurity and weak transport infrastructure, post-harvest losses in some regions can be between 30% and 50%. Put another way: Ethiopia imported over 1 million tonnes of grain for its needs but lost over 2 million in post-harvest losses in 2010 (US DoS, 2013). About 18% of milk is lost in India because of inadequate cold-chain storage. About 30% to 40% is lost post-harvest from the horticulture of both India and Bosnia and Herzegovina.

The greatest post-harvest loss in developing countries along the food production chain is the result of a combination of harvest methods, handling, storage, processing, packing and transportation. Consumption waste (from market to home to intake) is limited. There are three major challenges: poor storage (crushing fresh produce, lack of cold storage), lack of training (e.g. about sound grain storage management) and limited data (on the extent of post-harvest loss at any specific phase of production and distribution) (US DoS, 2013).

Better storage and a much improved food production-consumption ratio could reduce the global demand for production at farm level significantly and increase food security in countries with poor populations. In El Salvador, distribution of 133,000 metal silos has reduced losses by 11% and improved food security for 16% of the rural population (USDoS, 2013). Although there are still data gaps in this area, the scale of loss and the potential for gain warrants significant and immediate attention. As with livestock, consideration must also be given to the demand side. A significant amount of fresh food is wasted during

37 Climate-smart agriculture approaches aim to increase yields, reduce vulnerability to climate change and reduce greenhouse-gas emissions.

food processing and preparation in developed countries: 95 to 115kg a year is wasted by consumers in Europe and North America, compared with only 6 to 11kg a year in sub-Saharan Africa and Southeast Asia (FAO, 2011). Raised awareness about food waste, best-before dates and purchase planning in developed countries is required, alongside alternatives for unwanted food that is still edible. This may not be a direct poverty-eradication pathway, but should be viewed as an important element of system productivity. As the UN FAO urges: 'In a world with limited natural resources (land, water, energy, fertilizer)… reducing food losses should not be a forgotten priority' (FAO, 2011).

d. The challenge: agricultural industrialisation, growth and emissions

Agriculture has been the engine of growth in the past for most of the world's economies. It needs to be again, particularly for those poorest countries that are dependent on agriculture in their economy. But now agricultural development needs to be held within the bounds of lower carbon emissions and with a focus on its natural resource base. Agriculture must reduce its contribution to increased GHG emissions and land degradation, and ensure that it does not worsen the poverty and livelihoods of the most vulnerable. However, low emission agricultural development has not historically been a policy priority for nations dealing with significant poverty. In fact, many poor countries are very sceptical of low emissions approaches, or indeed anything that is perceived as a hindrance to their ability to feed their nations or gain maximum growth from agriculture.

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, and 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.

Agro-industrial intensification is premised on its ability to increase yields dramatically and thereby generate economic growth, reduce food insecurity and reduce the amount of landed needed for agricultural production. However, increases in yields from large-scale farming are not guaranteed: increased mechanisation can damage fragile soils and prove problematic to operate; significant investment is needed in market demand, in understanding soil productivity levels, and in improving farmers' ability to adapt to changing market demands and prices (Wiggins, 2009). Large-scale and intensified agricultural production also raises equity concerns and, therefore, poverty concerns: consolidation of agricultural land and production can limit the economic benefits accruing directly to the rural poor, or even marginalise them further (Deininger and Byerlee, 2011). Karlsson's (2014) recent study of impacts of foreign agricultural investment in developing countries showed that large scale land acquisitions can have negative effects for local communities, natural resources and livelihoods. This is particularly the case where land rights are limited and governance is poor.

While agroindustrial 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 towards the zero extreme poverty goal. The FAO has demonstrated that a relatively long timeframe is needed for investments to come to fruition, and strong support for farmers and the investor-farmer relationships (Karlsson, 2014). Tanzania's Southern Agricultural Growth Corridor approach has come under fire for earmarking nearly one third of Tanzania for commercial farming projects and putting aside the country's most fertile land for private investors, rather than working with farmers to reduce poverty (Provost and Kabendera, 2014).

The maximisation of agricultural productivity for economic growth may also present climate challenges by driving extensification. A successful model will be expanded and repeated; and those displaced by an expanding model may be pushed to marginal land areas, or new land areas, increasing overall emissions. Brazil's cattle ranching shows a good example where profitable systems have increased returns to land but also encouraged deforestation as the crop frontier expands into available land. This market driven intensification is particularly notable when commodity prices are high (Byerlee, 2014; see Box 4).

Interestingly, Brazil also provides a powerful example of the ability to limit extensification in high-yield and economically productive agricultural sectors. It has demonstrated initial success in reducing deforestation from Brazil's soy production sector since a 2006 moratoria on soybean production in forest areas was declared. Political will at government level was strong – Brazil had declared a target of 36-39% reduction in emissions by 2020 against business as usual. This was combined with an influential international campaign linking international industries to environmental destruction and was strengthened by a financial pledge from Norway as part of The Amazon Fund and a series of supportive actions from civil society. By 2009/10, only 0.25% of soybean production was produced on deforested land (Boucher, 2014). At the same time, analysis shows that Brazil's deforestation moratoria on the agricultural frontier has not hindered economic development (Assunção and Rocha, 2014).

e. Conclusion

The above raises significant questions about the ability of agroindustrialization to generate significant poverty reductions in the near term, even if it is capable of generating growth that could be instrumental in sustaining reductions. There is also significant evidence that small farms work: they are relatively more productive per hectare than large scale plantations, on the whole (UNEP, 2013). Sustainable smallholder agriculture provides a potential poverty-reducing pathway towards Zero Zero, but faces the challenge of increasing its productivity amongst the poorest countries of the world. Pretty et al (2006) showed impacts from 198 projects demonstrating significant increases in yields (one to eight-fold) from sustainable agriculture techniques and lower emission approaches including intensification, new crops or production methods, better use of natural resources on farm and appropriate crop and animal selection. While there are, therefore, examples of this being achieved, this is no small task to accomplish at scale. Is the same sort of success possible amongst the 500 million smallholders of the world?

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 skills and capacity, as well as greater social protection alongside strong governance of those who are unable to benefit from these changes.

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. These include tackling post-harvest losses, better livestock management, and ensuring that productivity and intensification are "bounded" by effective land use governance to ensure that increase yields do not translate into increased forest conversion.

Even with some identified synergies between the Zero Zero goals, aligning both the poverty and emissions reduction goals within agriculture, and reorienting from 'least resistance' BAU pathways for agricultural productivity, will require an unprecedented investment in the human capital, the natural capital, agricultural techniques, innovations and technologies, alongside strong political engagement. A zero extreme poverty agricultural transformation must, on the other hand, either greatly expand the resource productivity and employment opportunities within the sector and at scale, or enable a significant demographic shift away from agricultural jobs without creating further poverty. A zero net emissions pathway for an agricultural transformation would require intensification alongside significant institutional capacity capable of reining in extensification where land-use conversion creates an unsustainable emissions pathway.

Box 4. Brazil's cattle intensification plans

Brazil's cattle-ranching sector has been earmarked within Brazil's landmark policy goal of reducing emissions by 35 to 39% against business as usual by 2020. As cattle ranching is such a high producer of GHG emissions, Brazil has emphasised the possibility of increasing intensity of farming on cattle ranches, reducing further deforestation and effectively 'sparing' new land and possibly existing land, for pasture production. Whilst it is clear that intensifying cattle production through the various 'Cattle Ranching Intensification Program' activities increases productivity, as an emission reduction approach, this still may not work.

First, there are reasons why cattle ranching is extensive in much of Brazilian Amazonia – ranchers do not only ranch for cattle production, but to speculate on land, secure land tenure and receive government subsidies, and access to market is costly and limited, and diseases more problematic in tropical areas. Incentives for specific land uses are driven by geographic and political context.

Second, greater productivity in a global market where meat demand is increasing, may lead to greater intensification, not the 'land sparing' that might be assumed (Cohn et al., 2011). Indeed, with global market demand increasing, Brazil's intensification is expected to rise, to increase beef production by 2.5 million tonnes by 2023 (Rabobank, 2014). Rabobank claims that because of the costs and efficiencies needed for this, 4.8 million hectares of pasturelands are being freed up – 'for conversion into grain areas by 2023' (Rabobank, 2014 p.4).

3. The human habitat transition

a. Habitat, poverty and climate change

Human habitat is changing. By 2050, two-thirds of world population will be urban (UNDESA, 2014). 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. Asia and sub-Saharan Africa will urbanise the fastest between now and 2050 (UNDESA, 2014) and cities in these regions will soon contain a sizeable share of the extreme poor. Decent housing conditions, convenient and affordable transport as well as access to basic services (water, sanitation, and electricity) are critical to eliminating income and multidimensional poverty.

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), and virtually all of those are in developing countries.

b. The promise of cities

No country in the world has been able to develop without the growth of its cities (World Bank, 2009). 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). Marking substantial modifications to the built environment, urbanisation underpins economic transformation and sustained economic growth has always been accompanied by urbanisation (World Bank, 1999). That cities are capable of generating so much income and wealth strengthens the case for 'urbanising' development (Sassen, 2009). The confluence of capital, people and space unleashes the benefits of agglomeration, with greater social and economic interactions creating a fertile environment for innovation in ideas, technologies and processes. Cities can, therefore, be a driver of poverty reduction.

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. It is estimated that 724 of the largest cities in the world could reduce emissions by as much as 1.5 billion tonnes of carbon dioxide equivalent per year by 2030 through these means (NCE, 2014).

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. A large number of the urban poor live in slums, marked by inadequate access to safe water, sanitation and infrastructure, low structural quality of housing, overcrowding and insecure residential status. Air pollution and environmental distress have a disproportionate effect on the urban poor, whose health and productivity suffer as a result (Satterthwaite, 2007; Seto and Dhakal, 2014). Access to education can be quite limited, and vaguely defined property rights can reduce the ability to accumulate assets and plot a long-term course out of poverty. At the same time, cities account for 70% of global energy use and the most prevalent urban development models result in considerably higher emissions intensity than might be expected for a zero net emissions pathway (NCE, 2014).

Leveraging the advantages of concentration, proximity and scale, 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.

c. Opportunity: prioritising urban form

Urban form – the quality of the built environment, the type of transport system, and overall spatial planning – plays an instrumental role in determining if urbanisation will result in synergy between emissions reductions and poverty eradication, or will fail to serve either. It is not urbanisation per se, but the specific types of urban systems that we have developed to handle production, consumption and distribution of goods and services that dictate our progress towards eradicating extreme poverty and dealing with climate change (Sassen, 2009).

Interestingly, a common set of government and market failures drive both anti-poor and high-emission patterns of urban development. These include:

- The failure to assign property rights and titles for land.
- The failure to account for the social benefits of spatial amenities and mixed land uses.
- The failure to account for the social benefits of agglomeration that result from the interactions of individuals and firms.
- The failure to account for the social costs of air pollution and water contamination that result from production and consumption activities.
- The failure to account for the social costs of traffic congestion and accidents (Seto and Dhakal, 2014).

Correcting these specific market failures or removing the dysfunctional aspects of urban systems is a critical step in the right direction. More broadly, improving the industrial processes by which we extract, make, package, distribute and dispose of the foods, services and materials we use is also crucial to ensuring the sustainability of production supporting urban growth (Sassen, 2009). Most of all, creating a robust and mutually reinforcing Zero Zero pathway requires a categorical restructuring of the urban form.

Urban form is characterised through four key metrics: density, land use mix, connectivity and accessibility (IPCC, 2014d), described in Table 9 opposite. Urban form can create synergies between the goals of zero extreme poverty and zero net emissions and serve as a critical entry point for improving the quality of urbanisation. The densification of human populations with optimal land-use, the construction of environmentally sound infrastructure and improved mobility can catalyse a smooth transition to low-carbon pathways and avoid the lock-in of wasteful patterns of energy, consumption and lifestyle.

The purposeful and strategic use of space and available land, coupled with low energy intensity, can also lower costs and generate both social and environmental dividends to all urban populations and the wider ecosystem.

Table 9. Elements of urban form

Element of Urban Form	Characteristics	Making urban form pro-poor
Compact form	High population density, high employment and high built-up area density can minimise commuting costs and distances and encourage healthier and climate-friendly modes of transport (IPCC, 2014d). Benefits aside, recent evidence points towards a decline in both population and built-up area density (IPCC, 2014d; NCE, 2014), which makes **land-use** planning a greater priority.	Reduced travel distances and costs, as well as the reduced cost of service delivery can be of particular benefit to the poor if their living spaces are incorporated in the core urban centres.
Mixed and integrated land uses	Integrating different land uses (for residential, commercial and greening purposes), measured in terms of the ratio of jobs to residents, the availability of a range of amenities and activities, and the relative proportion of retail and housing (IPCC, 2014d) can enhance 'liveability' aspects of our habitat systems.	Mixed land use is an important compliment to densification. Densification in the absence of mixed land uses can isolate urban populations away from goods, services and amenities. Critical, and often most challenging, is ensuring the poor can gain land title to informal settlements and/or access to financing to acquire housing. Similarly, public policy needs to support markets in ensuring sufficient properties (for sale or rental) are available for people at all income levels.
Connectivity	Connectivity reduces travel distances between different parts of the city. Better street and road connections, pedestrian pathways and traffic flow can ease pressures on commuters and reduce carbon emissions (IPCC, 2014d).	Infrastructure choices to facilitate connectivity can be pro-poor, if access those services is made available to the poor (both financially and behaviourally). Pedestrian pathways and public transport, for example, can be a significant means of fostering connectivity of poor people. However, roads have only partial utility, as they tend to be designed for automobile users, and highways are by their nature exclusive to automobile users.
Accessibility	Access to jobs, housing and services, especially those linking people to places, in tandem with the other three elements of urban form can magnify the benefits of proximity (IPCC, 2014d).	From a poverty perspective, accessibility to jobs, housing, and services is one of the most significant benefits of urbanisation. However, these dimensions of accessibility require key pro-poor public policy choices, especially in terms of affordability. They are not a consequence of urban migration itself.

d. The challenge: cities, migration and capacity

The dynamics of rural to urban migration can also degrade poor people's quality of life, or merely shift poverty and vulnerability from a rural to an urban form. Urban development is often poorly planned (if planned at all) and poorly executed, resulting in an aggregate economic growth story that is undermined by a large informal sector. Characterised by declining market conditions for jobs, housing and basic amenities, the informal sector disproportionately hurts poor people and delays poverty eradication efforts.

For example, in many Chinese cities today, rural migrants are unable to access a wide range of services to which urban residents are entitled. This reality collides with a primary purpose of migration: to gain better access to services. The Chinese hukou system, in which citizens are grouped into rural and urban hukou, has allowed government authorities to limit service provision. Even though some benefits – such as free immunisation, family planning and employment services – are open to migrants under the 'blue stamp urban hukou', facilities such as training allowances, minimum living guarantee, and affordable housing are only available to urban hukou holders. Although less formalised in most poor countries, such dualism and disenfranchisement is endemic, breeding inequality and sharpening the rural-urban divide (Zhang et al., 2014; McGranahan and Satterthwaite, 2014; World Bank and the PRC, 2014).

In parallel, vulnerability to climate change is also more pronounced in cities. Large concentrations of people and economic activity in coastal areas increases disaster exposure, especially with regard to flooding. In a seminal study by Hallegatte et al. (2013), in which present and future flood losses are estimated for 136 of the largest coastal cities, costs were estimated to approach $1 trillion per year due to climate change. In many developing-country cities - Guangzhou, Guayaquil, Ho Chi Minh City, Abidjan, Zhenjiang, Mumbai, Khulna, Palembang, and Shenzhen - it is poor people who are most at risk. Rapid urbanisation, poor planning and lack of access to capital has pushed them into highly vulnerable neighbourhoods, often in low-lying areas and along waterways frequented by floods (World Bank, 2013d). At the same time, from a mitigation perspective, unplanned, sprawling, lower-density urban patterns with inefficient public transport and high automobile use drive high per capita GHG emissions (Satterthwaite, 2007), just as they drive some of the worst consequences for the poor.

Although achieving zero net emissions and zero extreme poverty in urban centres can be broadly complementary, they are not the same thing. It is quite possible to drive a lower-emissions urban form that largely benefits the rich, emission-intensive citizens, while leaving poor people trapped in low-consumption and low-emissions patterns. Similarly, it is possible, even if not efficient, to improve the living conditions of the urban poor through additional sprawl and poorly-coordinated service provision. There must be a conscious decision to drive both objectives for the complementarities to be realised, with positive densification and concentration effects leveraged to enhance the 'liveability' of the poor (Evenden, 2014).

Changes to existing urban form entail critical trade-offs, especially for specific parties with an interest in the status quo. Incumbents in real-estate development, transport provision, waste disposal services, among others, may be threatened, and the political economy of such a transformation must be managed to ensure that the collective benefits outweigh the particular costs.

Finally, there remains the fundamental implementation challenge. As human habitat systems undergo massive change in the next few decades, with the percentage of people living in urban areas increasing from 54% in 2014 to 66% by 2050 (UNDESA, 2014), the tools to manage this change are not always readily available. Managing such a complex transition requires a corollary institutional transformation, spanning from the mechanisms for planning and stakeholder inclusion to the instruments for revenue raising and procuring services.

e. Conclusion

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 they could drive a radical transformation by 2030 and beyond. Opportunities exist to design more compact, better-connected cities, and 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 improves 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 as well as utilising 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 prioritise the poverty or climate exigency and thereby make it even more difficult to achieve both, or they can 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 conception 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; and basic services that are reliable, affordable and clean (Evenden, 2014).

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 aimed explicitly at ensuring growth, emissions reductions and poverty eradication, the strong fundamental complementarities of such a model can catapult us to a Zero Zero world.

VII. Conclusions

1. 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.

Work by the IEA suggests that countries with large numbers of people in extreme poverty will require about $5 trillion in investment for measures related to energy efficiency by 2030, and another $1-2 trillion for investment in clean energy if they are to reach zero net emissions. Work by the FAO suggests that an additional $200 billion could be required for actions related to the agriculture sector in Africa alone (Branca et al., 2013), an amount that could easily double if extrapolated to India and Southeast Asia. A recent analysis by the NCE suggests that the reductions in other investment requirements (such as infrastructure related to fossil fuels) could cut this amount by half to two-thirds. Nevertheless, an incremental increase in investment of even $2-4 trillion represents a significant increase in required capital investment[38], often in countries that are perennially short of any capital to invest. In addition, as the previous section 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 to accelerate existing efforts to provide capital to poor countries, and to 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, although it needs to be scaled up to meet the needs of countries with sizeable numbers of extremely poor people and work in combination with development finance to create a win-win outcome. At the same time, care is needed to ensure that 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). What's more, 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 that can deliver compensatory transfers effectively to poor people, and services that are designed to meet their needs from the outset. Experience here is, however, mixed. For example, efforts to reduce fossil-fuel subsidies while compensating poor people for losses to their well-being have failed in many cases (Clements et al., 2013). It is clear that pro-poor outcomes require more than improved technical capacity: that capacity needs to be delivered to poor people – they need to feel its benefits. Decades of experience with 'extension services' has shown that 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 both the structural transformation and the related policy ambition 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, rather than technical, processes (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). So, 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.

38 Total gross capital formation in sub-Saharan Africa and India was roughly $1 trillion in 2013, and total gross capital formation across all low and lower-middle income countries was only about $1.5 trillion in 2013 (World DataBank – World Development Indicators).

2. Achieving Zero Zero is possible and necessary

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, and this 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, clean water, for example – have only a small impact on GHG emissions.

In another sense, however, the eradication of extreme poverty may depend on the achievement of zero net emissions. There are very plausible scenarios in which the climate change associated with a BAU scenario will create persistent and irremediable poverty, with the potential to keep hundreds of millions of people in poverty through and beyond 2030. This 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 vulnerable to poverty well into the second half of the century. And it will remain true even 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 the least-developed countries) and only partially effective.

In contrast, a pathway towards 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 emission (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), and 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 and improving infrastructure choices, better managing natural capital, increasing productivity and competitiveness, and 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 that climate action could generate a modest increase in growth (perhaps by around1% by 2030) for the LDCs, while reducing growth only moderately (perhaps by around1-3%) 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.[39]

Indeed, a strategy focused on equitable growth to eradicate poverty could complement the structural changes involved in a pathway towards 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, reinforcing 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. And even where unavoidable trade-offs exist, these appear to be relatively smaller and very manageable, especially for LDCs and in the context of international support. To manage this pathway effectively, however, these countries will require far more capital and far greater institutional capacity and technical skills than they have at present, and this represents a significant challenge to be overcome.

One thing is clear however: *neither* of the goals – zero extreme poverty or zero net emissions – are compatible with business as usual. Reaching zero extreme poverty and maintaining progress toward zero net emissions will require fundamental structural shifts in major economic systems, no matter what. Addressing the poverty and climate challenges together, however, offers the opportunity of a single, robust and mutually reinforcing transition. Tackling them separately seems likely to be far less effective. This means, therefore, that both domestic priorities and international aid priorities need to focus on a combined Zero Zero pathway. The need for international climate support remains immense, but this analysis suggests that the returns to this support (in terms of growth and poverty reduction in poorer countries, as well as lower global emissions) could also be immense, if well-directed toward combined and transformational change.

39 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.

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